THE FOREST FIRE PROBLEM IN THE TERRITORY OF THE APPALACHIAN FOREST EXPERIMENT STATION AND A FIRE RESEARCH PROGRAM

By

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INTRODUCTION

From the time the first settlements were made on the Atlantic Coast until the last western wilderness was explored, it became increasingly evident that the United States was blessed with a tremendous forest wealth. No country in the world could boast of such huge reservoirs of timber and such a wide variety of useful species. Partly from necessity but mostly because of a typical human disregard of the future in times of plenty, this resource was gradually used and destroyed until today many sections of the country feel the economic and social repercussions resulting from unwise use of their "unlimited" forests.

The outstanding agent of forest destruction and deterioration in this country has been and still is fire, or, fire followed by insects and disease. In the early days settlers had a perpetual struggle with the forest to get room to grow crops. Fire was a necessary tool in agriculture. Carelessness with fire, however, often resulted in the destruction of forests on non-agricultural land. Later, many logged-over areas were intentionally or accidentally burned, often repeatedly, until all chance for natural regeneration was eliminated or delayed for years.

No region in the country can be proud of its forest fire record and no region can feel that its fire problem has been solved. It is significant, however, that adequate fire protection is universally recognized today as the first essential consideration of good forest management.

In the Appalachian region, like all others, fire directly or indirectly has destroyed tremendous amounts of timber. Probably because of the light character of fires in most types, the people here have not been fully aware of the harm caused by repeated burning. Also, in hardwood forest types the sprouting capacity of trees tends to hide quickly the damage effected by fire.

Description of the Appalachian Region

In order to appreciate the fire problems and their significance, one should have a clear picture of the territory of the Appalachian Forest Experiment Station which embraces all of Virginia, West Virginia, North Carolina, South Carolina, and northern Georgia, eastern Tennessee, and eastern Kentucky.

Principal subdivisions

The region is divided into three main physiographic sections, Coastal Plain, Piedmont, and mountains. The mountain area occupies slightly more than half of the region with 64 million acres compared to 26 million for Piedmont and 34 million for Coastal Plain. These three main subdivisions may be further split up on the basis of major soil types shown in figure 1. These give rise to differences in forest cover which in turn create variations in the fire problems that will be brought out later.

The Coastal Plain extends from sea level to 600 feet in elevation and occupies a strip along the Atlantic Coast approximately 125 miles wide. The Piedmont is characteristically a foothills region of rolling and broken terrain, varying from 600 to 1,000 feet in elevation. The Appalachian Mountains run from southwest to northeast, the southern portion being rugged and rough with numerous peaks above 5,000 feet. The highest peak east of the Continental Divide -- Mt. Mitchell, 6,684 feet -- lies in western North Carolina. The mountains form a series of parallel ridges in Virginia and West Virginia and are not as rugged and high as farther south. Thus, from a physiographical standpoint, the region is extremely complex.

Forest types and acreages

Pine and swamp hardwood types characterize the coastal plain area while in the mountains the forests are composed almost entirely of broadleaved species with spruce on the higher mountains and small areas of pine or pine-hardwoods in the valleys or on lower slopes. The Piedmont is a transition area and contains primarily pine-hardwood types. Figure 2 shows the distribution of principal forest types in the region.

In general, the region is heavily forested, particularly on the Coastal Plain and in the mountains. Here, individual counties have as much as 85 percent of their area covered by tree growth. Three-fourths of the region is 51 to 75 percent forested as shown by figure 3, and 60 percent of the entire area is forest land. Table 1 gives exact areas in mountains, Piedmont, and Coastal Plain that are forested.

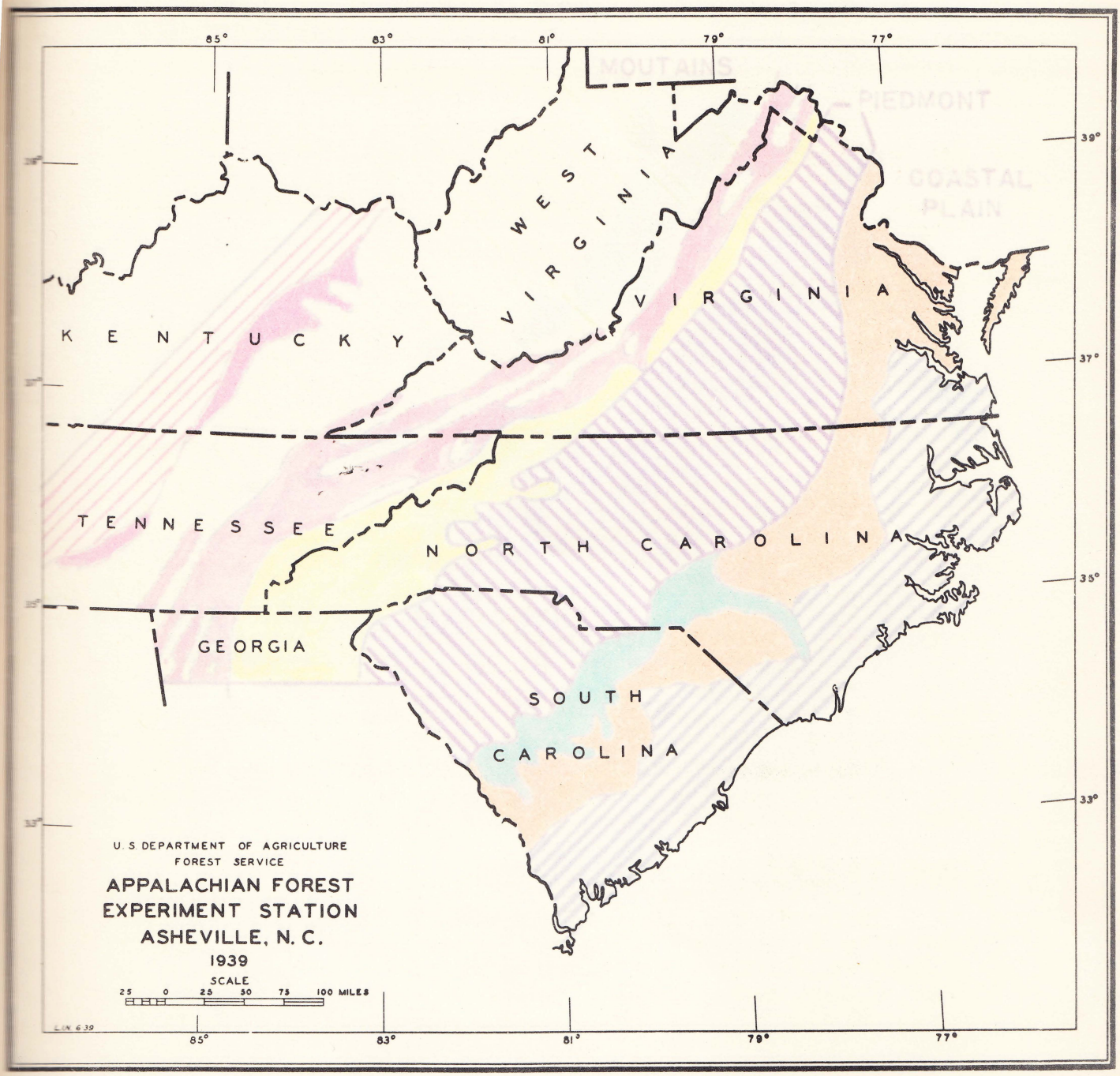
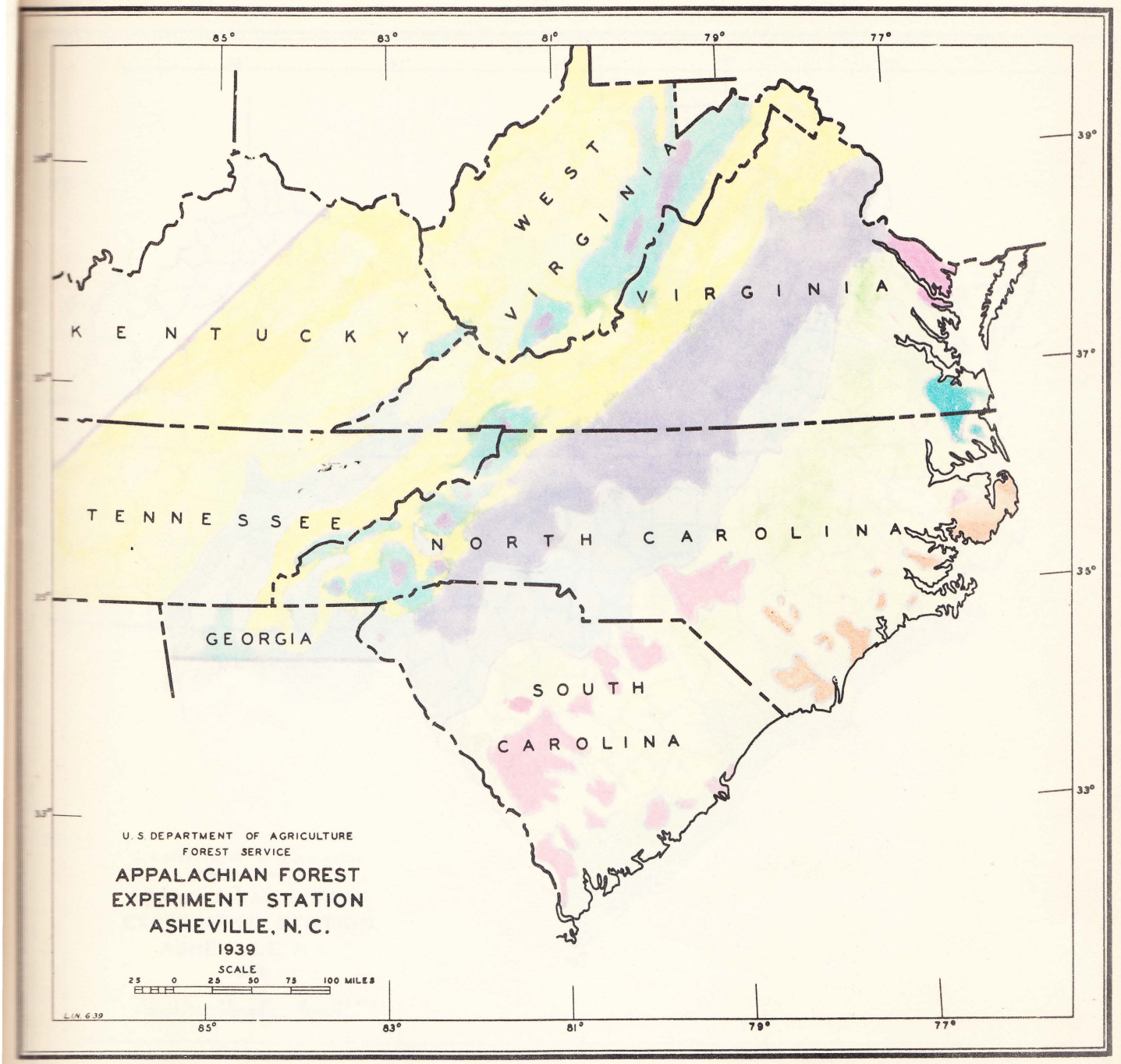


FIGURE 1.—PRINCIPAL SUBDIVISIONS AND SOIL TYPES OF APPALACHIAN STATION'S TERRITORY.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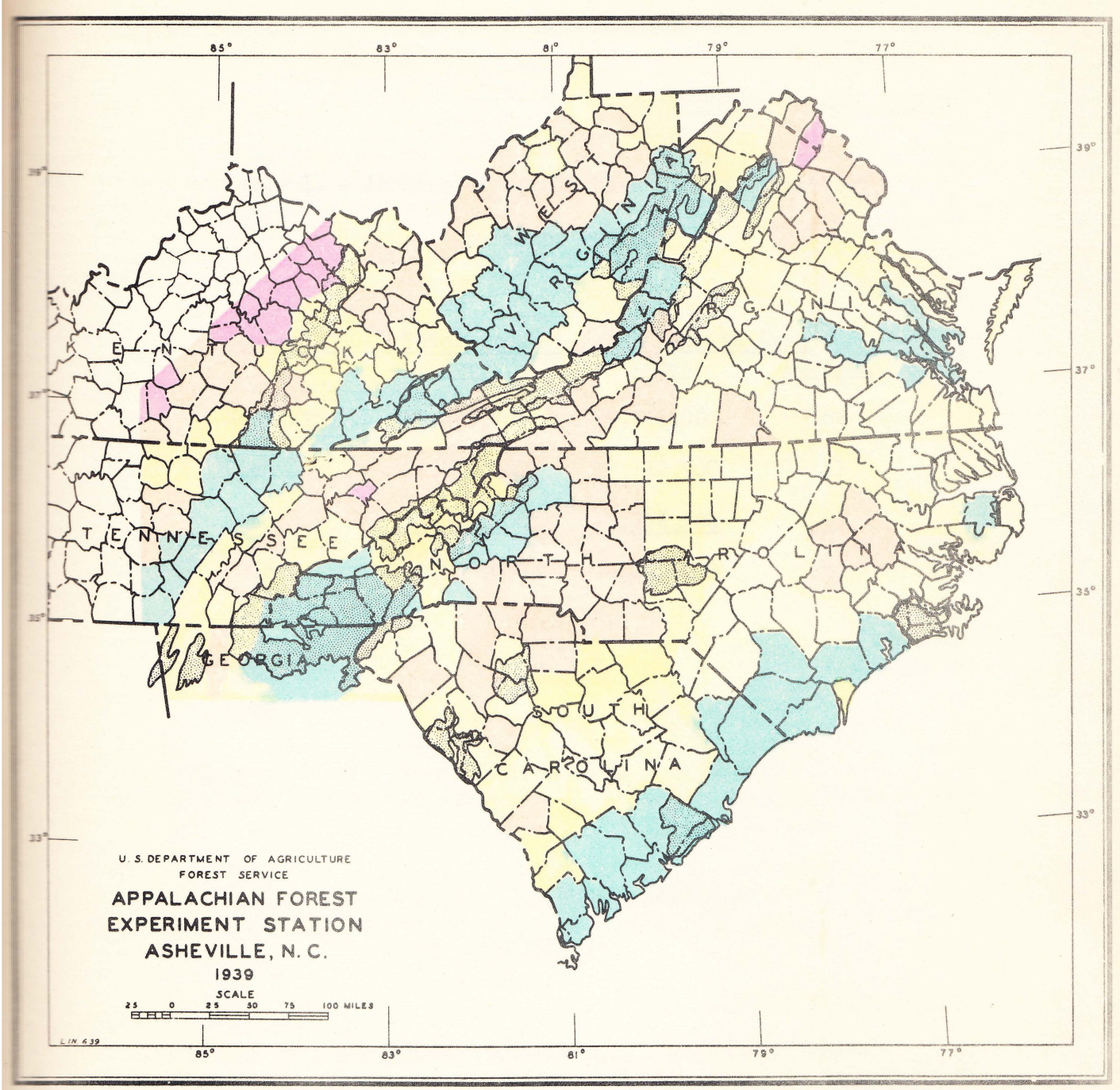


FIGURE 3.—PERCENT OF TOTAL LAND AREA IN FOREST.

0 — 25 percent forested
26 — 50 " "
51 — 75 " "
76 — 100 " "

Table 1. - Acreage of Appalachian Station territory by major regions

Region	Total Area	Forest Area	
	Acres	Acres	Percent
Mountains	63,683,700	39,715,000	62
Piedmont	25,709,400	13,112,900	51
Coast	33,806,900	21,372,100	63
Total	123,200,000	74,200,000	60

Table 2 presents acreages of condition classes found in the three main subdivisions.

Present timber volumes

The timber wealth of the region is great, as brought out by table 3. Of the 136 billion board feet inventoried or estimated by the Forest Survey, 66 percent is second growth or under sawlog size. Fifty-four percent of the net volume in the region is located in the Carolinas and one-half to two-thirds of this amount is of the fire resistant softwood species. The other states, particularly Kentucky, Tennessee, and West Virginia, are most depleted by cutting and undoubtedly by fire since easily damaged hardwood types prevail in these sections. The mountain subdivision has almost twice the forested acreage of the Coastal Plain, yet it supports 10 billion board feet less timber. Repeated burning is responsible to a large extent for this condition in the slower growing and easily damaged hardwood types. The following tabulation shows net timber volumes by subregions.

Subdivision	Total net volume Thousand feet b.m.	Fraction of total Percent
Mountains	50,651,300	37
Piedmont	24,797,900	18
Coastal Plain	60,788,800	45
Total	136,238,000	100

For the region as a whole, about one-third of the timber volume is in softwoods. Percentages of total volume that are softwoods follow:

South Carolina	- 59%	Virginia	- 50%
North Carolina	- 64%	West Virginia	- 12%
Georgia (northern)	- 69%	Kentucky	- 13%
		Tennessee	- 20%

Forest land ownership

Private ownership of forest land predominates in the Appalachian region as shown in figure 4. There are a variety of other agencies that own forests, however, and there are some differences in the type of private ownership that have an important bearing on the job of fire protection. Private forest land ownership (exclusive of farm woodlots) in figure 4 has been divided into three even percentile groups. The map shows that large estates and timber company holdings are concentrated in two zones, one along the coast and the other in the Appalachian Valley and Cumberland-Allegheny Plateau. Little of the other private forest land, particularly in the Piedmont, is in large ownership blocks. It is in this section where small farm woodlots predominate.

Table 2. - Acreages in forest condition classes by sub-regions

Condition class[1]	Coastal Plain and Piedmont			
	Coastal Plain		Piedmont	
	Area	Total forest land	Area	Total forest land
	Acres	Percent	Acres	Percent
Abandoned crop land	472,800	2.2	629,400	4.8
Clear cut or burned	467,600	2.2	26,200	0.2
Reproduction	1,709,800	8.0	498,300	3.8
Cordwood, second-growth	6,582,600	30.8	5,389,400	41.1
Sawtimber, second-growth	9,019,000	42.2	5,258,300	40.1
Sawtimber, old growth	3,120,300	14.6	1,311,300	10.0
Totals	21,372,100	100.0	13,112,900	100.0

Condition class[2]	Mountains		
	Approximate age range	Forest area	Total forest area
	Years	Acres	Percent
Open - unstocked		1,588,600	4
Reproduction	1-20	11,914,500	30
Second-growth - primarily cordwood	21-40	12,311,650	31
Second-growth - cordwood & sawtimber	41-80	7,943,000	20
Second-growth - primarily sawtimber	81-120	3,177,200	8
Mature - sawtimber	121 +	2,780,050	7
Totals		39,715,000	100.

1/ Condition classes for Coastal Plain and Piedmont correspond with the Forest Survey classification.

2/ Condition classes for Mountains correspond essentially with national forest classification. Descriptive terminology has been added.

Table 3. - Present net timber volume by the International ¼-inch rule, classified by forest condition[1]/

State and subdivision	Forest Condition					
	Old growth		Second growth		Under sawlog size	Total
	Uncut	Partly cut	Uncut	Partly cut		
	Thousand feet b. m.					
South Carolina						
Southern coastal plain	2,347,100	1,135,900	4,814,100	774,400	338,000	9,409,500
Northern coastal plain	3,869,300	2,728,400	6,151,200	1,626,400	447,100	14,822,400
Piedmont	846,500	732,500	2,557,500	1,479,200	348,600	5,964,300
Total	7,062,900	4,596,800	13,522,800	3,880,000	1,133,700	30,196,200
North Carolina						
Southern coastal plain	2,264,300	2,341,900	4,653,300	2,335,000	666,500	12,261,000
Northern coastal plain	2,061,600	2,461,600	6,055,000	3,417,000	340,700	14,335,900
Piedmont	974,800	1,814,600	5,300,300	2,403,900	590,000	11,083,600
Mountains	851,900	894,900	2,105,600	843,700	413,900	5,110,000
Total	6,152,600	7,513,000	18,114,200	8,999,600	2,011,100	42,790,500
Georgia						
Northern district	818,500	479,200	3,171,700	784,300	297,600	5,551,300
Virginia						
Coastal Plain	3,030,000		6,930,000			9,960,000
Piedmont	1,860,000		5,890,000			7,750,000
Mountain	1,770,000		2,670,000			4,440,000
Total	6,660,000		15,490,000			22,150,000

See footnote at end of table.

Table 3. - Present net timber volume by the International $\frac{1}{4}$-inch rule, classified by forest condition[1] -- Continued

State and subdivision	Forest Condition					
	Old growth		Second growth		Under sawlog size	Total
	Uncut	Partly cut	Uncut	Partly cut		
	Thousand feet b. m.					
West Virginia						
Total	3,180,000		5,670,000			8,850,000
Kentucky						
Total	4,500,000		5,250,000			9,750,000
Tennessee						
Total	4,780,000		12,170,000			16,950,000
Grand total	45,743,000		87,052,600		3,442,400	136,238,000

[1]/Data for South Carolina, North Carolina, and northern Georgia are from published Forest Survey reports. All other figures are revisions of Copeland Report estimates prepared by the Forest Survey staff for the recent Congressional Committee report. As is evident in the table figures for the "under sawlog" size class are incomplete.

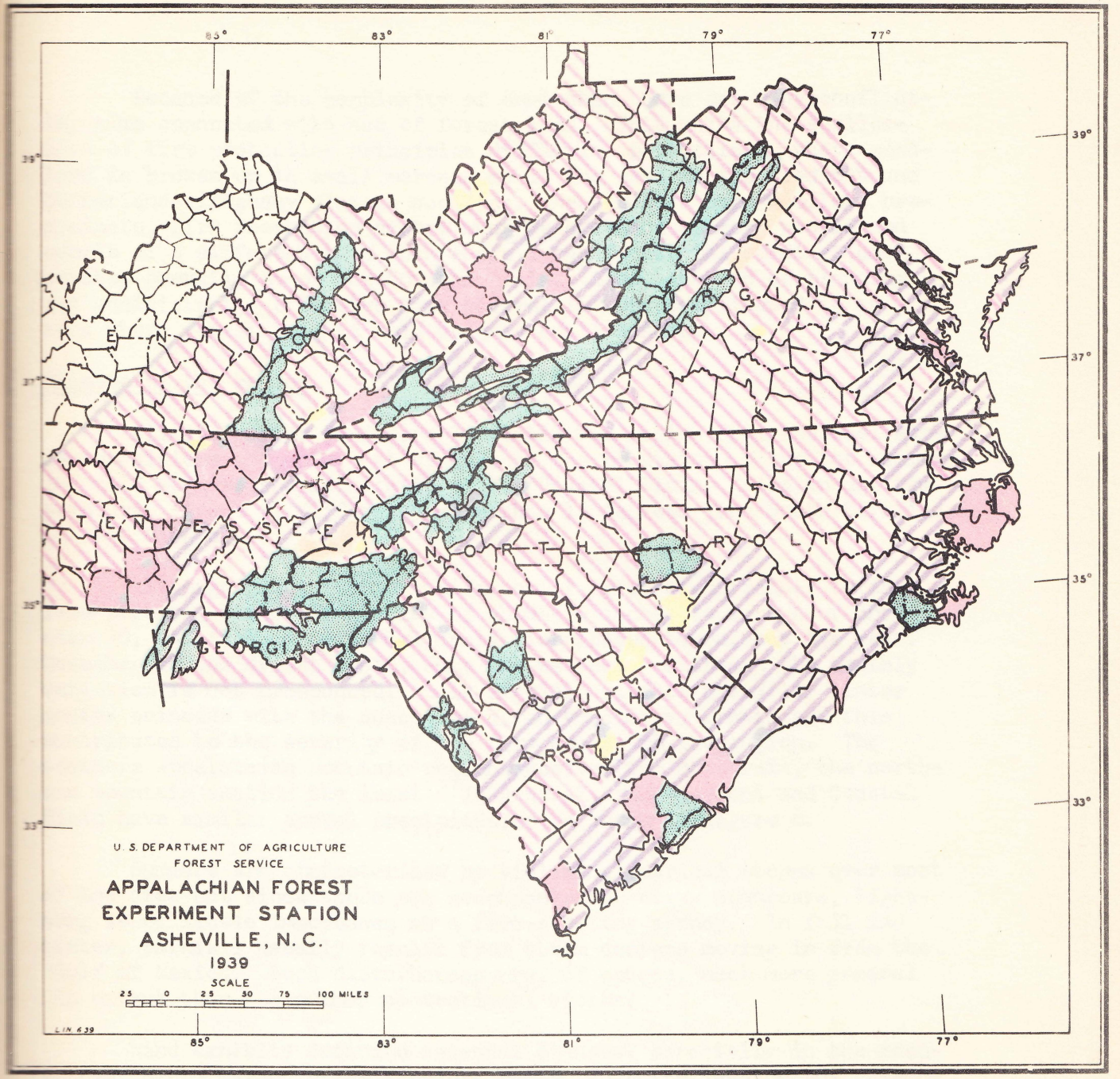


FIGURE 4.-FOREST LAND OWNERSHIP WITH SPECIAL REFERENCE TO LARGE PRIVATE HOLDINGS.

Because of the complexity of ownership there are many conflicting aims connected with use of forest land. This makes the application of fire protection principles difficult, particularly where woodland is broken up in small parcels as is the case in the Piedmont and Cumberland-Allegheny plateau sections. Here, where farm woodlots predominate, fire prevention effort must be expended on more people and people of a different type than where large industrial holdings and estates prevail, as on the Coastal Plain. Also, the job of planning and administering effective fire control is more complicated in an area where forest land is held by many small owners.

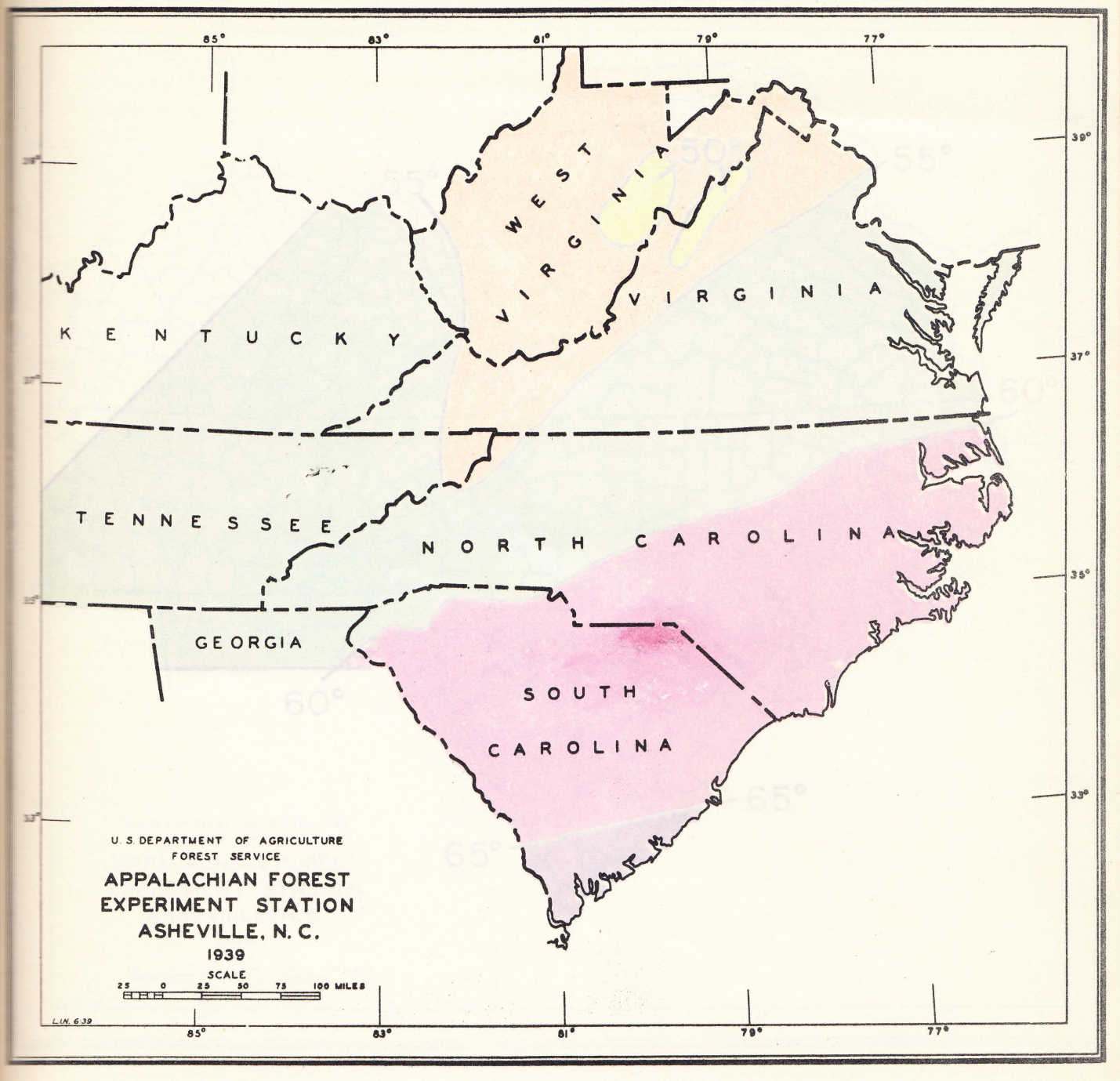
Climate of the region

Climate varies considerably within the region from the cool summer conditions and cold, wet winters in the mountains to the hot summers and mild winters characteristic of the Coastal Plain. Mean annual temperature, figure 5, differs by more than 15 degrees from South Carolina to West Virginia.

Although precipitation, a factor of great significance to the fire problem, varies from a low of about 35 inches to a high of more than 70, rainfall is quite uniformly distributed throughout the year. November is the driest month, July the wettest. Although the monthly variation is not pronounced, it is significant that the drier winter months coincide with the season of cured vegetative growth and this contributes to the severity of the fire danger in the region. The southern Appalachian Mountain region receives the most rain, the northern mountain section the least. In general, the Piedmont and Coastal Plain have similar annual precipitation as shown in figure 6.

Summers are characterized by violent electrical storms over most of the area but since these are accompanied by heavy downpours, lightning is of little importance as a fire-starting agency. In fall and winter, rainfall usually results from storm centers moving in from the Gulf of Mexico. Such disturbances are, of course, much more general in extent than the summer convectional storms.

Wind exhibits definite seasonal changes, especially in the mountains. Here, March is the windiest month, July the least windy. There is a very uniform gradation between these extremes. Coastal Plain and Piedmont have the highest wind averages; that is, if high mountain-peak winds are excluded. The latter have little bearing on the fire situation because so few fires start at extreme elevations in the mountains. Winds in the mountains are much more variable in force and direction than winds in rolling or level country. In hardwood types, during the leafless season, wind penetrates the forest and is of greater significance to fire conditions than during the green period when dead ground fuels in which fires start and spread are sheltered.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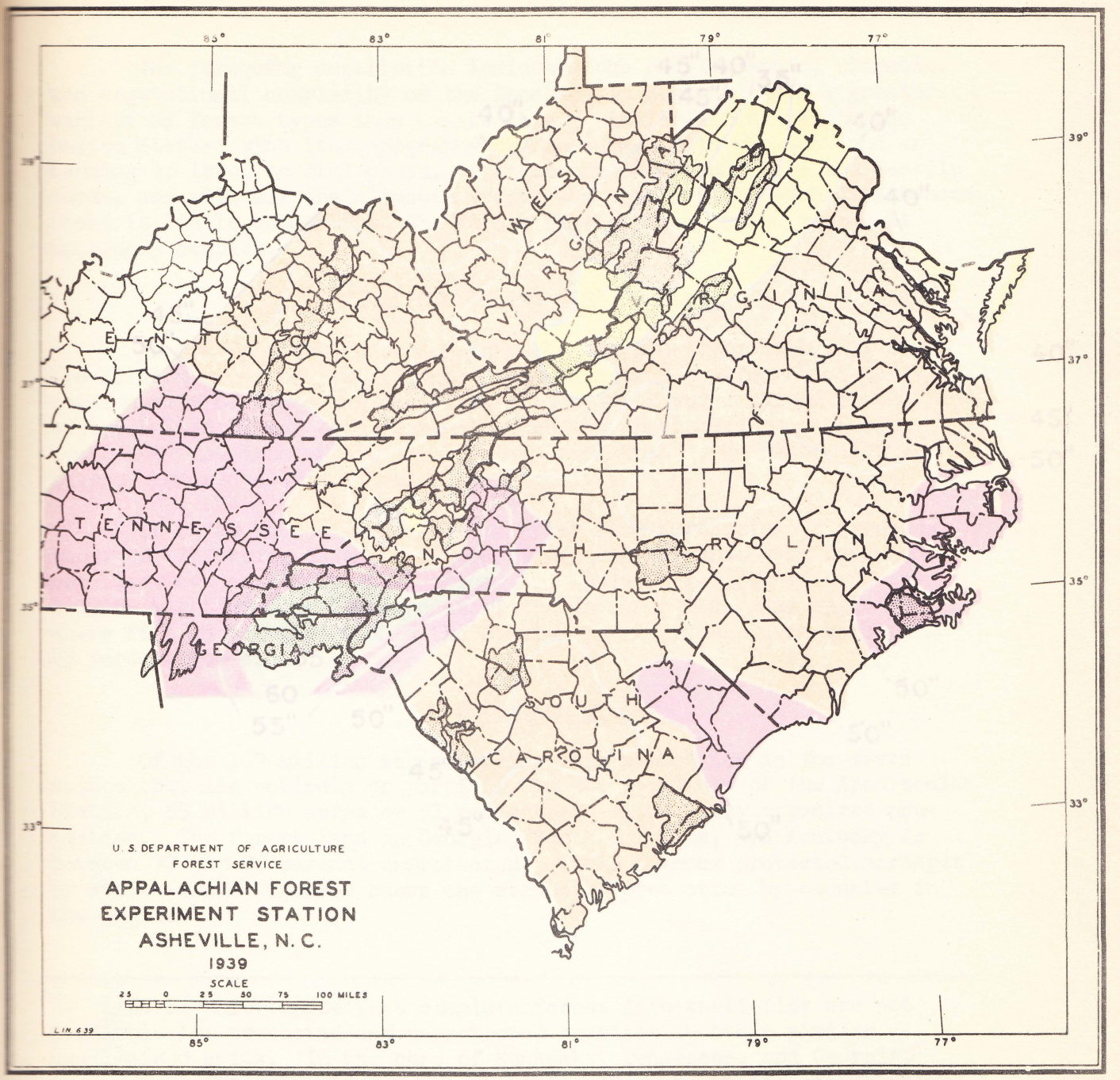


FIGURE 6.—MEAN ANNUAL PRECIPITATION.

The foregoing description indicates the physiographic, climatic, and vegetational complexity of the Appalachian region. With a greater variety of forest types than exists in any similar-sized area in the United States; with its topography the most rugged in the East and extending to level coastal plain, with unproductive sand hills and fertile coves, and with all the climatic variations that go with such differences, there is little wonder that the forest fire problem in the region is extremely complex.

ANALYSIS OF THE FIRE PROBLEM[1]/

In the Appalachian region more than 44,000 fires each year burn 6.8 million acres of forest land. This is nearly one-fourth of the total number of fires and one-fifth of the total acres burned in the entire United States each year, although the Appalachian region contains but one-sixth of the country-wide area that needs protection.[2]/ Figure 7 presents this relation graphically.

There is no one large area in which fire protection is unnecessary. By referring again to figure 3, one can see that only isolated counties have as little as 25 percent of their area forested. An exception might be made in the case of the Kentucky Bluegrass region where fifteen counties within the Station territory are from zero to 25 percent forested.

Protected Area

Of the 109 million acres needing fire protection in the seven states that lie entirely or partially in the territory of the Appalachian Station, 55 million acres or 51 percent are without any organized protection. The forest land in Georgia, South Carolina, and Kentucky is between 70 and 90 percent unprotected. Table 4 shows protected acreages by states while figure 8 shows the status of protection by counties in the region.

1/It is unfortunate that complete forest fire statistics are not available for protected and unprotected counties or other similar small-sized units. In the case of Kentucky, Tennessee, and Georgia, it has been necessary to present statistics for the entire states rather than for the portions of them that lie within the Station territory. It is believed that the conclusions based on such statistics are unaffected by this fact and for all practical purposes, further refinement of basic data is not highly essential.

2/Area considered as needing protection includes all timber land, cut-over land, farm woodlots, forest pasture, etc. It does not include agricultural land, non-woodland pasture, or barren areas.

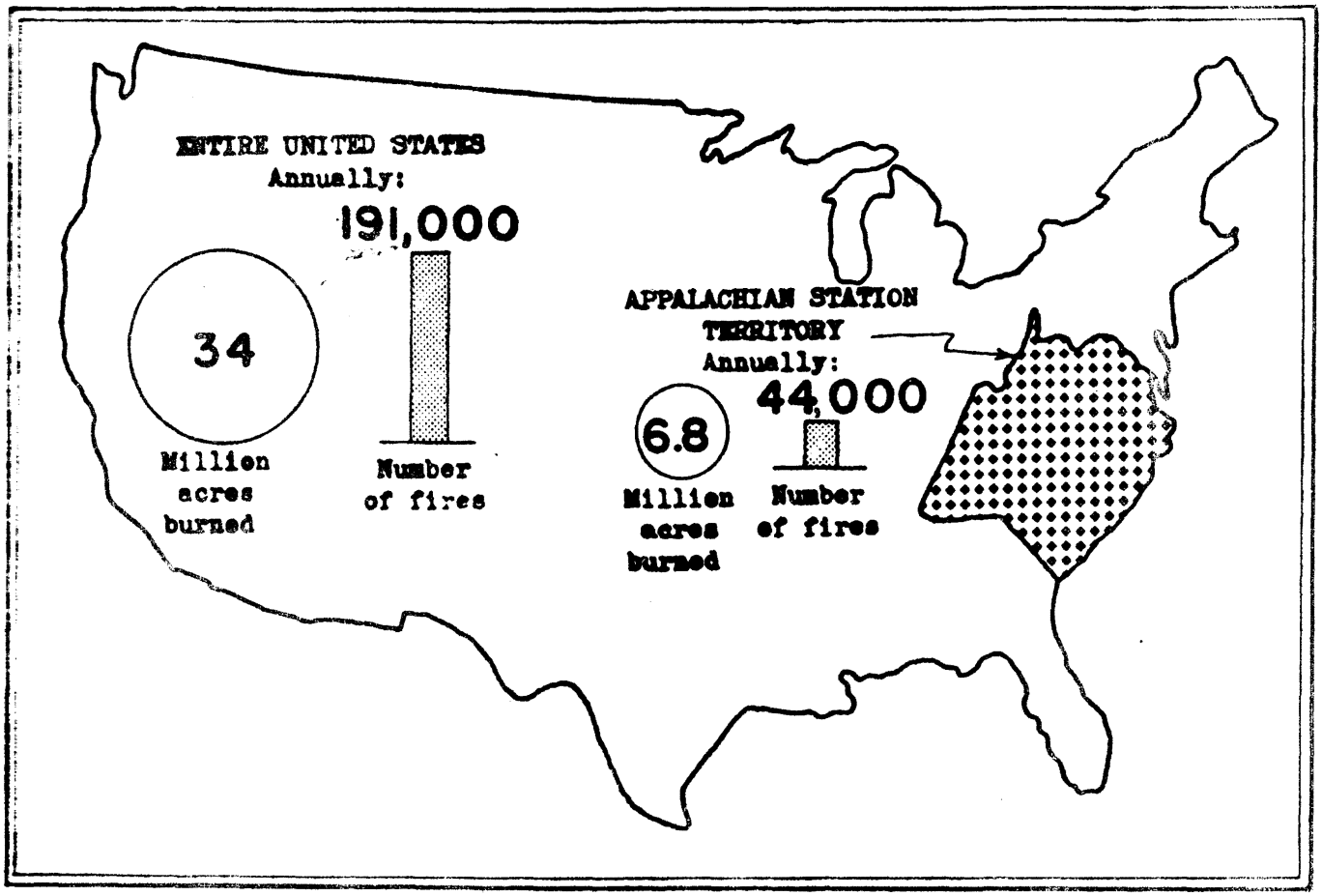


Figure 7. - Comparison of Appalachian Region and the United States.

Table 4. - Protected and unprotected acreages, 1934 to 1938 averages[1]/

State	Total area needing protection	Area being protected				Area without protection
		Federal	State and private	Total		
	Millions of acres				Percent	Millions of acres
Georgia	23.75	0.56	4.38	4.94	20.8	18.81
Kentucky	9.56	0.36	0.91	1.27	13.3	8.29
North Carolina	21.63	1.11	13.61	14.72	68.1	6.91
South Carolina	13.21	0.39	3.58	3.97	30.1	9.24
Tennessee	12.78	0.73	7.46	8.19	64.1	4.59
Virginia	17.46	1.25	11.41	12.66	72.5	4.80
West Virginia	10.53	0.79	7.02	7.81	74.2	2.72
Totals	108.92	5.19	48.37	53.56		55.36
Average					49.2	

1/From "Forest fire statistics for the United States", U.S.D.A., Forest Service. 1938.

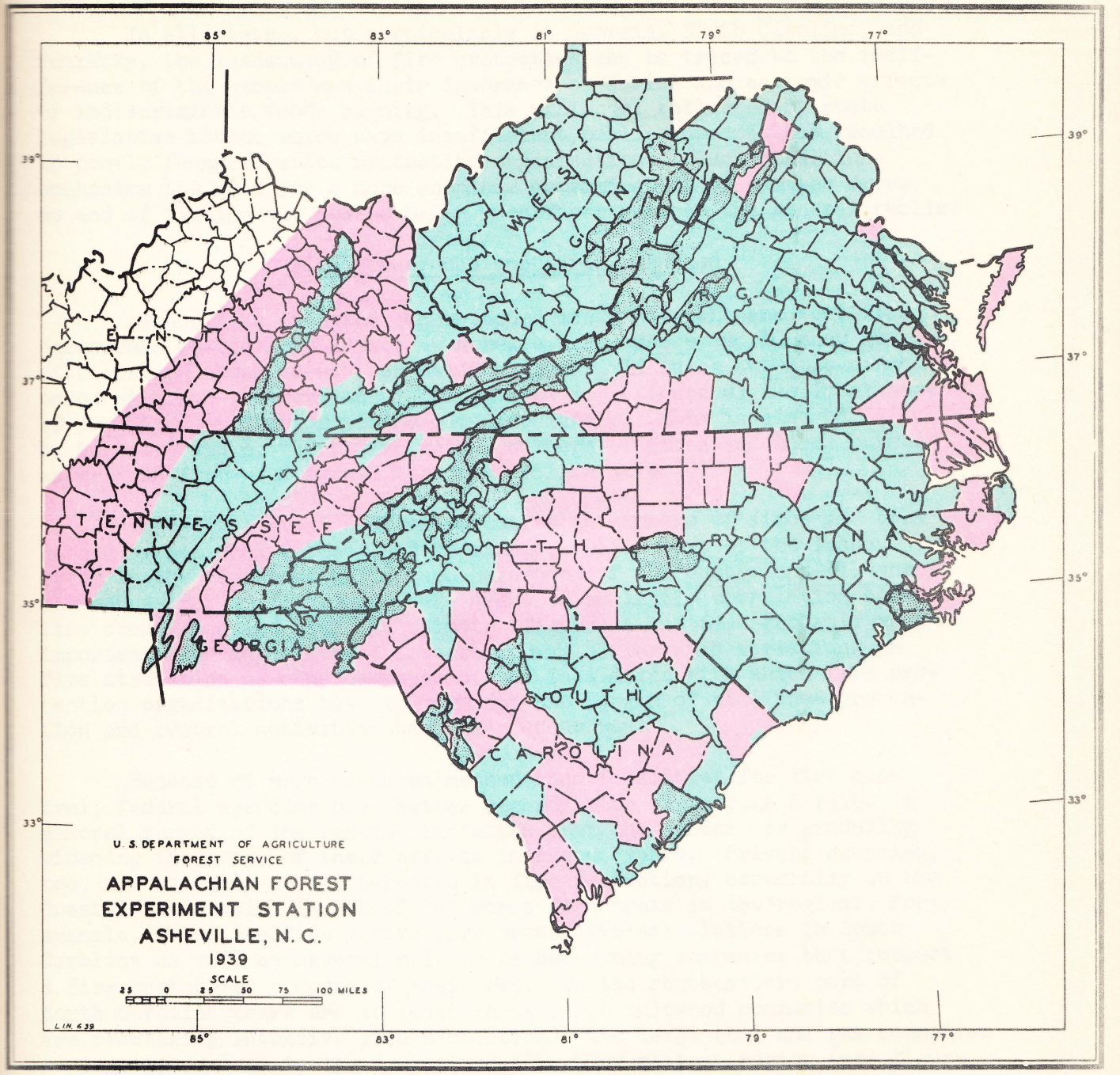


FIGURE 8.— PROTECTED AND UNPROTECTED FOREST LAND.

Protected

Unprotected

In all states, but particularly in Georgia, South Carolina, and Kentucky, the inadequacy of fire protection can be traced to the indifference of the people and their ignorance of social and economic effects of indiscriminate woods burning. This attitude, reflected by state legislative bodies which have insufficient public support, has resulted in poorly financed state protective organizations. Such conditions emphasize the need for a more complete determination of damages fires do and of finding out how to bring such facts home to the general public.

Fire Occurrence and Acreage Burned

As would be expected, unprotected lands have the greatest fire occurrence and largest losses in acreage. Figures 9 and 10 show number of fires and acres burned per million acres. If these two maps are compared with the protected-unprotected area map (figure 8) the importance of organized protection stands out immediately. This is also borne out by tables 5 and 6, which give actual numbers of fires and acres burned as well as fires and burned area per million acres.

There is a great deal of variation in numbers of fires and area burned by national forests and by states. While most of the losses occur in the pinewoods and upland hardwoods of the Cumberland-Allegheny plateau (refer to figure 2) there seems to be little correlation between fire occurrence and size and climate (figures 5 and 6). Probably more important than any of these factors in explaining such variations in fire statistics is consideration of the facilities with which fire protection organizations have to work and the length of time that prevention and control activities have been under way.

Because of more advanced methods and facilities for fire control, federal agencies have better records than states, as a rule. A general survey of the records indicates that the states are gradually widening the scope of their efforts in recent years. Private agencies, too, are becoming more interested in fire protection, especially on the Coastal Plain which is one of the worst fire areas in the region. For example, there are five active fire protective associations in South Carolina as well as several private timber-owning companies that support a fire protection program of their own. In the southeastern part of North Carolina there are at least three large pulpwood companies which are practicing intensive fire protection. The large coal and gas companies owning timber land in the Cumberland-Allegheny plateau region (see figure 4) have done little, however, in the way of organized protection.

The value of organized fire protection is well illustrated in table 6 which shows for the seven states considered only 1.5 percent of protected area burns each year while almost 11 percent is burned on unprotected forest land.

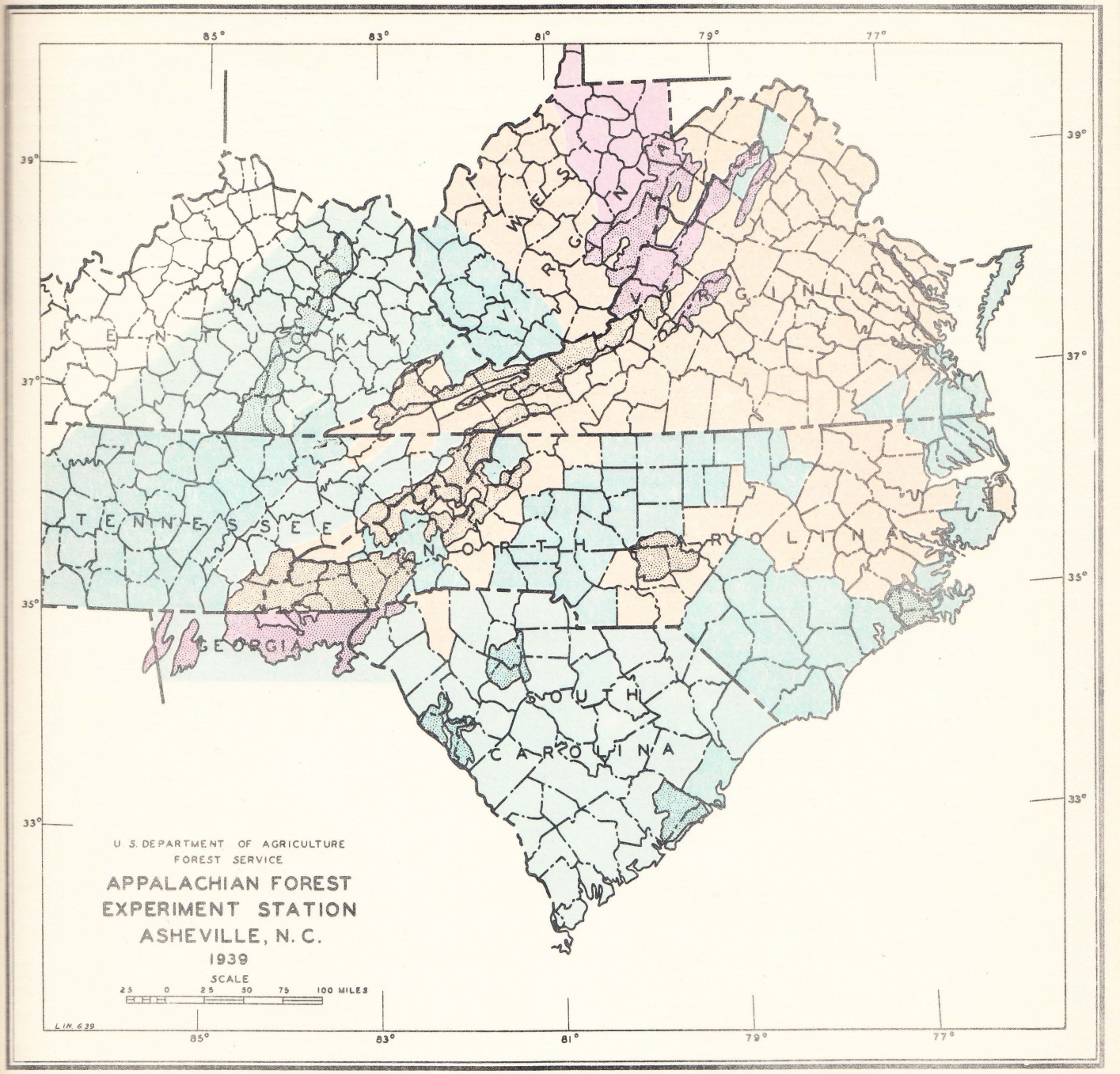


FIGURE 9.— AVERAGE NUMBER OF FIRES PER YEAR PER MILLION ACRES OF FOREST LAND.

100 or less
101 to 250
251 to 500
501 or more

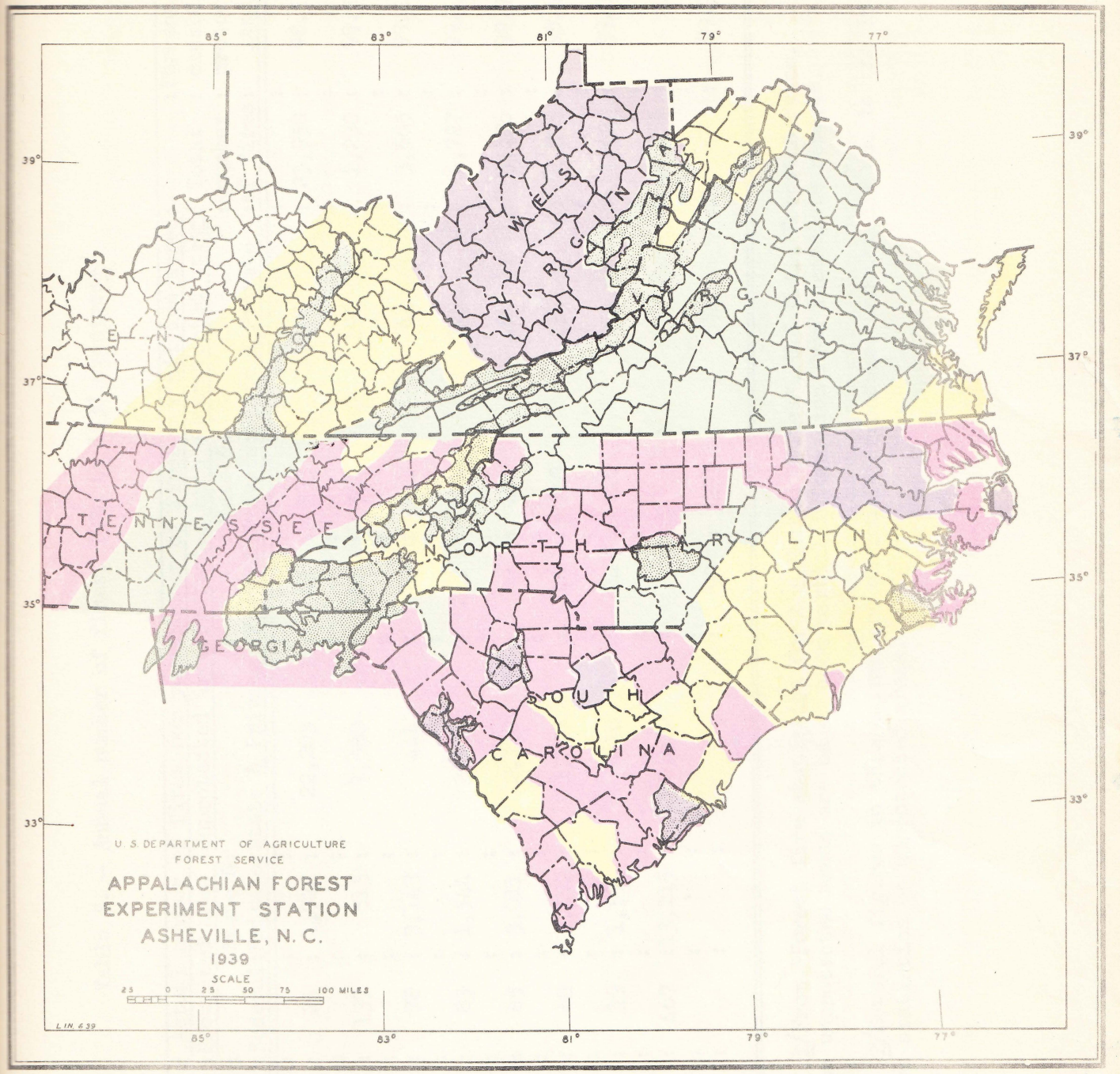


FIGURE 10.—AVERAGE NUMBER OF ACRES BURNED PER YEAR PER MILLION ACRES OF FOREST LAND.

Table 5. - Annual number of fires, 1934 to 1938 averages[1]

State	Actual number of fires per year: Protected area: Federal	Actual number of fires per year: Protected area: State & Private	Actual number of fires per year: Unprotected area: State & Private	Number of fires per million acres: Protected area: Federal	Number of fires per million acres: Protected area: State & Private	Number of fires per million acres: Unprotected area[2]: State & Private	Total number of fires	Percent man-caused on protected land
Georgia	25	1,722	22,203	45	393	1,180	23,950	98.5
Kentucky	137	513	1,580	381	564	191	2,230	99.5
North Carolina	78	3,143	444	70	231	64	3,665	99.1
South Carolina	83	1,544	3,100	213	431	335	4,727	99.4
Tennessee	65	3,011	2,110	89	404	460	5,186	99.7
Virginia	60	1,592	1,223	48	140	255	2,875	98.4
West Virginia	19	1,594	10	24	227	4	1,623	99.7
Total	467	13,119	30,670				44,256	
Average				90	271	554		99.2

1/From "Forest fire statistics for the United States", U.S.D.A., Forest Service. 1938. Data for fires on unprotected areas are based upon partial information from incomplete reports.

2/Several figures in this column are obviously erroneous, undoubtedly due to the incompleteness of fire statistics on unprotected areas.

Table 6. - Annual area burned on protected and unprotected forest lands, 1934 to 1938 averages1/

State	Actual area burned per year			Area burned per million acres			Area burned all land	Percent area burned annually	
	Protected area		Unprotected area	Protected area		Unprotected area 2/		Protected land	Unprotected land
	State & Federal	State & Private	State and Private	State & Federal	State & Private	State and Private			
	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Percent	Percent
Georgia	364	182,748	4,451,386	650	41,723	236,650	4,634,498	3.71	23.66
Kentucky	1,142	26,634	161,968	3,172	29,268	19,538	189,744	2.19	1.95
North Carolina	1,784	186,508	325,062	1,607	13,704	47,042	513,354	1.28	4.70
South Carolina	4,306	45,086	610,096	11,041	12,594	66,028	659,488	1.24	6.60
Tennessee	1,234	227,494	390,252	1,690	30,495	85,022	618,980	2.79	8.50
Virginia	1,290	44,280	58,774	1,032	3,881	12,246	104,344	0.36	1.22
West Virginia	574	68,448	725	727	9,750	267	69,747	0.88	0.03
Total	10,694	781,198	5,998,263				6,790,155		
Average				2,060	16,150	108,350		1.48	10.84

1/From "Forest fire statistics for the United States", U.S.D.A., Forest Service. 1938. Data for fires on unprotected areas are based upon partial information from incomplete reports.

2/Several figures in this column are obviously erroneous, undoubtedly due to incompleteness of fire statistics on unprotected areas.

Causes of Fires

In the Appalachian region, 99 percent of fires are man-caused (table 5) with incendiary fires heading the list at an average of 27 percent of the total occurrence. Smokers and debris burners follow in that order. These three agencies are important in every state and account for 67 percent of all fires. Except for fires classified as "miscellaneous" and "unknown", campers are next in importance as a fire-starting agency.

Table 7 shows that only 2.3 percent of all fires have been traced to lumbering activities, and lumbering together with railroads is responsible for only 6 percent of all fires. The primary responsibility for starting fires rests squarely upon the incendiary, the land-clearing farmer, and the recreationist. Thus the fire prevention problem is well defined as it must be aimed at three specific classes of people.

The largest acreage burned is generally associated with the most frequently-operating causative agencies. Complete statistics of acres burned by causes for each state are given in table 8.

Periodicity of Fire Occurrence

Fire occurrence is extremely seasonal in all portions of the region as shown by figure 11. In the hardwood types (Eastern Region) there is a high peak of occurrence in April with a smaller one in November. In the pine types of the south, March and April are the "fire months".

High spring-time occurrence is due to the operations of debris burners and, since the woods are highly inflammable at this period of the year, incendiaries are very active. The high March and April risk is made worse by the fact that normal wind velocities peak in these months. The November peak of occurrence in the mountains coincides with the driest part of the year.

A significant feature of the fire problem in the East and South is the occurrence of fire in every month of the year. This requires some protection effort, continuously.

Annual Damage

Damage by fire is extremely difficult to evaluate because of its intangible or indirect effect. Even some of the so-called direct effects, such as mortality, are obscure in hardwood stands where injured trees may not die for four or five years after a burn.

Table 7. - Number and percent of fires on protected land by causes, 1934 to 1938 averages[1]/

State		Lightning	Railroad	Campers	Smokers	Debris Burning	Incendiary	Lumbering	Misc.	Unknown	Total
Georgia	No.	26	64	53	41	159	788	22	439	155	1,747
	%	1.5	3.7	3.0	2.3	9.1	45.1	1.3	25.1	8.9	100.0
Kentucky	No.	3	16	53	94	157	249	18	26	34	650
	%	0.5	2.5	8.1	14.5	24.1	38.3	2.8	4.0	5.2	100.0
North Carolina	No.	28	81	334	932	638	746	76	294	92	3,221
	%	0.9	2.5	10.4	28.9	19.8	23.2	2.4	9.1	2.8	100.0
South Carolina	No.	10	66	55	427	313	349	37	128	242	1,627
	%	0.6	4.1	3.4	26.2	19.2	21.4	2.3	7.9	14.9	100.0
Tennessee	No.	9	101	332	213	469	1,118	105	123	606	3,076
	%	0.3	3.3	10.8	6.9	15.3	36.3	3.4	4.0	19.7	100.0
Virginia	No.	27	106	69	531	351	180	39	87	262	1,652
	%	1.6	6.4	4.2	32.1	21.2	10.9	2.4	5.3	15.9	100.0
West Virginia	No.	4	75	62	661	360	291	19	141	----	1,613
	%	0.3	4.7	3.8	41.0	22.3	18.0	1.2	8.7	----	100.0
Total	No.	107	509	958	2,899	2,447	3,721	316	1,238	1,391	13,586
	%	0.8	3.7	7.1	21.4	18.0	27.4	2.3	9.1	10.2	100.0

[1]/From "Forest fire statistics for the United States", U.S.D.A., Forest Service. 1938.

Table 8. - Acreage burned on protected land by causes, 1934 to 1938 averages[1]

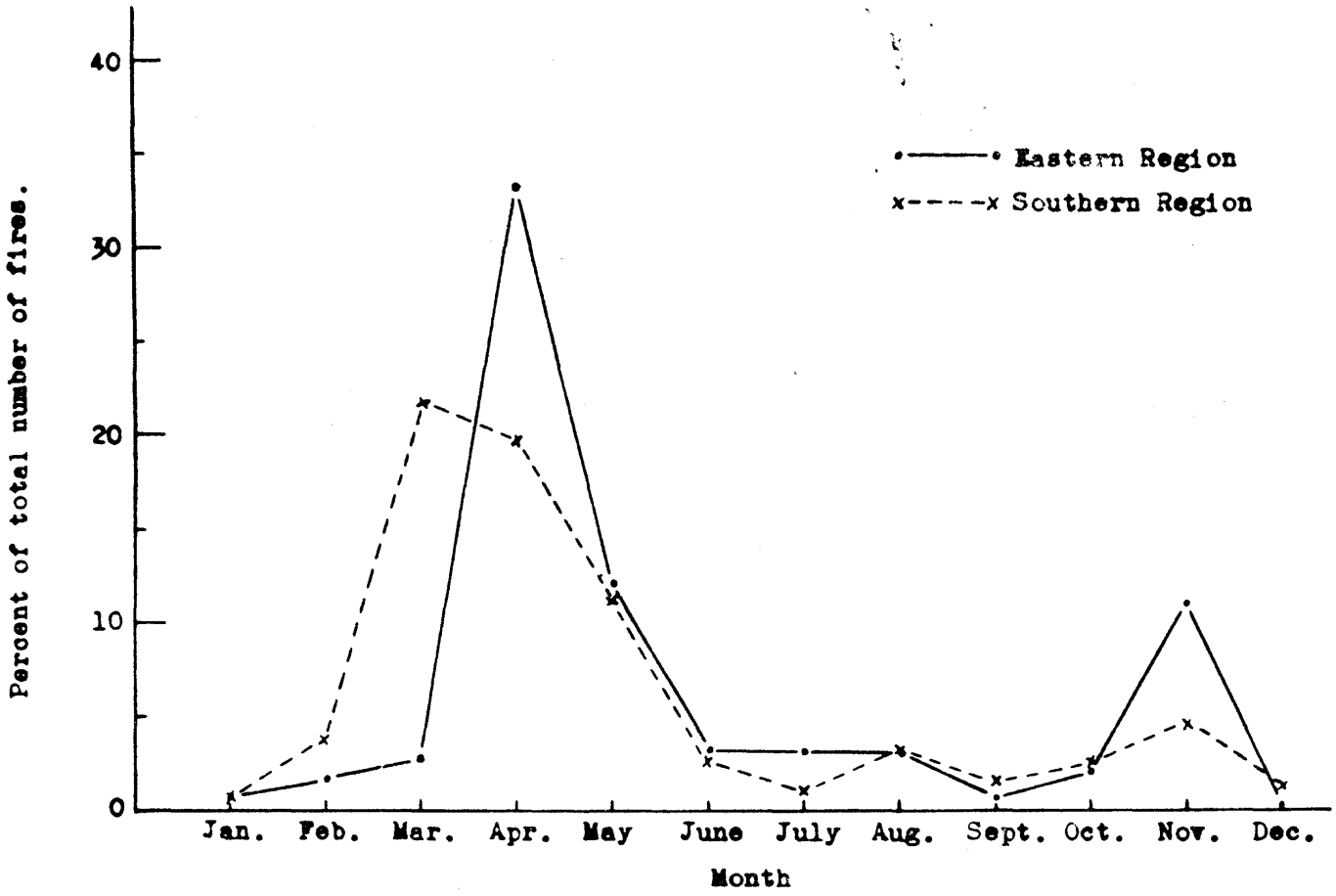
State		Lightning	Railroad	Campers	Smokers	Debris Burning	Incendiary	Lumbering	Misc.	Unknown	Total
Georgia	Acres	742	3,124	2,744	1,066	11,984	102,412	5,708	41,474	13,858	183,112
	%	0.4	1.7	1.5	0.6	6.5	55.9	3.1	22.7	7.6	100.0
Kentucky	Acres	10	252	2,140	1,824	8,072	10,350	1,336	636	3,156	27,776
	%	0.0	0.9	7.7	6.6	29.0	37.3	4.8	2.3	11.4	100.0
N. Carolina	Acres	4,592	2,404	19,128	41,978	32,846	54,680	8,288	16,536	7,618	188,070[2]
	%	2.4	1.3	10.2	22.3	17.5	29.1	4.4	8.8	4.0	100.0
S. Carolina	Acres	120	1,100	1,394	8,514	8,402	14,276	1,976	4,846	8,764	49,392
	%	0.3	2.2	2.8	17.2	17.0	28.9	4.0	9.8	17.8	100.0
Tennessee	Acres	42	3,660	23,758	10,700	32,906	88,800	9,536	6,888	52,438	228,728
	%	0.0	1.6	10.4	4.7	14.4	38.8	4.2	3.0	22.9	100.0
Virginia	Acres	258	1,896	1,460	11,132	10,968	7,818	1,226	2,582	8,230	45,570
	%	0.6	4.2	3.2	24.4	24.1	17.1	2.7	5.7	18.0	100.0
W. Virginia	Acres	104	3,382	3,116	27,972	12,838	13,838	1,422	6,350	----	69,022
	%	0.2	4.9	4.5	40.5	18.6	20.0	2.1	9.2	----	100.0
Total	Acres	5,868	15,818	53,740	103,186	118,016	292,174	29,492	79,312	94,064	791,670
	%	0.8	2.0	6.8	13.0	14.9	36.9	3.7	10,0	11.9	100.0

[1]/From "Forest fire statistics of the United States", U.S.D.A., Forest Service. 1938.

[2]/There is apparently an error of 222 acres in this figure as published. This total fails to check by this amount with that given in table 6.

Periodicity of fire occurrence in East and South.

(Computed from National Forest 10-day statistics, 3- to 5-year averages)
(November and December values approximate.)



It has been well established that the greatest damage from fire is to the younger age classes or small-sized trees. This is extremely significant in this region where 40 to 45 percent of all forest land in the Piedmont and Coastal Plain bears reproduction or cordwood-sized timber (see table 2); in the mountains, 61 percent of forest lands are classed as reproduction or cordwood stands. Thus, for the territory as a whole, more than one-half of the land is in age classes particularly susceptible to high fire damage.

Table 9, which contains the best tangible damage figures available, indicates an annual loss from fire of about $8,000,000 for the seven states under consideration. Eighty-three percent of this damage occurs on lands with no organized fire protection. The intangible and indirect damages probably are many times this figure. It is known definitely, for instance, that losses due to the decay that enters through basal fire wounds approach those of mortality in mountain hardwoods.

Forest Survey statistics for North and South Carolina (table 10) indicate relative damage to stands by timber types. Pine types have suffered the heaviest damage in the Coastal Plain where fire has been so prevalent in the past. Upland hardwoods have been damaged most severely in Piedmont and mountain areas. Species such as pond pine have suffered heavily because of the extreme severity of fires in this type. The Survey statistics indicate for North and South Carolina, as a whole, that 39 percent of all forest area shows some sign of fire damage.

From the foregoing it is apparent that extension of organized fire protection to the present unprotected forest land is desirable because 83 percent of the damage is occurring on 51 percent of the land. Organization, even on the present basis, which is inadequate in many cases, can reduce area burned to a sixth of what it is now. Since 99 percent of the fires are man-caused, prevention is the biggest job on all areas. Incendiaries, smokers, debris burners, and campers are the agencies upon which prevention effort must be expended.

SIGNIFICANCE OF THE FIRE PROBLEM

It is impossible at the present time to place a dollar-per-acre value on forest land in the region, including not only wood producing values, but those for watershed protection, grazing, game, recreation, and other indirect social values as well. The general importance of the intangible assets of a forest, however, give some insight into the significance of the fire problem.

Table 9. - Average annual tangible damage caused by fire, 1934 to 1938[1]/

State	Dollars damage			
	Protected land		Unprotected land	
	Federal	State & Private	State & Private	Total
Georgia	418	245,320	4,333,934	4,579,672
Kentucky	2,666	43,422	302,510	348,598
North Carolina	3,398	313,612	649,426	966,436
South Carolina	2,434	41,098	525,674	569,206
Tennessee	1,588	434,652	689,394	1,125,634
Virginia	6,670	99,428	132,902	239,000
West Virginia	792	156,562	555	157,909
Totals	17,966	1,334,094	6,634,395	7,986,455

1/This table does not include the vast amount of (intangible and indirect) damage resulting from forest fires, such as through decay, stand and soil deterioration, erosion, loss of wildlife, loss to recreation, etc. Figures for unprotected areas are based on partial information only, from incomplete reports. From "Forest fire statistics for the United States", U. S. D. A., Forest Service. 1938.

Table 10. - Fire damage by timber types in Coastal Plain, Piedmont and mountains. (Based on Forest Survey plot records.)

	Coastal plain				
	Longleaf pine	Pond pine	Loblolly pine	All pine	Bottomland hardwoods
Number of plots	4,339	2,399	5,606	12,344	3,666
No fire	677	53	790	1,520	1,547
Fire but no damage	1,579	233	2,223	4,035	822
Light damage	1,569	703	1,839	4,111	730
Medium damage	450	748	613	1,811	384
Heavy damage	64	662	139	865	183
Damaged plots	2,083	2,113	2,591	6,787	1,297
Percent damaged plots	48	87	47	55	35

	Piedmont			
	Loblolly pine	Shortleaf pine	All pine	Upland hardwoods
Number of plots	1,656	5,023	6,679	1,925
No fire	881	2,867	3,748	968
Fire but no damage	438	1,210	1,648	436
Light damage	243	682	925	371
Medium damage	84	238	322	138
Heavy damage	10	26	36	12
Damaged plots	337	946	1,283	521
Percent damaged plots	20	19	19	27

	Mountains			
	Yellow pine[1]	Other softwoods[2]	Cove hardwoods	Upland hardwoods
Number of plots	988	336	341	2,680
No fire	499	233	196	1,094
Fire but no damage	198	45	94	613
Light damage	212	39	37	669
Medium damage	64	14	12	249
Heavy damage	15	5	2	55
Damaged plots	291	58	51	973
Percent damaged plots	30	17	15	36

1/Includes pitch, shortleaf, and Virginia pine types.

2/Includes white pine, hemlock, balsam fir, and spruce types.

Present Economic Situation in the Region

Income

The Southeast is the poorest region in the United States from the standpoint of the personal income of its 17 million residents. Largely an agrarian country, its states generally rank the lowest in the nation in farmers' income. Virginia, which leads the group of states in the Appalachian section in farm income, ranks but fortieth in the entire United States. Table 11 shows the per capita income of farm and non-farm groups and the ranking of states and regions. It also shows that the estimated true wealth of the states in the Appalachian region ranks between twenty-seventh and forty-sixth in the United States.

Industry and agriculture

In five of the seven states in the Appalachian territory, manufacturing of clothing, textiles, and knit goods leads all industrial enterprises. In West Virginia and Kentucky steel and distilled liquor manufactures, respectively, are first in importance.

The manufacture of wood products, turpentine, and furniture rates high in all states except West Virginia as shown in table 12. Such industries rate second in South Carolina, Georgia, and Tennessee; third in Virginia, North Carolina, and Kentucky. These ratings are based on "values added by manufacturing" (a measure commonly used by economists), which are determined by subtracting costs of material and power purchased from the final value of the product. Thus, such data give a measure of economic importance of an industry to a region.

The Southeast leads the country in the number of forest-products manufacturing establishments. The following data, taken from Odum's "Southern Regions of the United States", give the number of such manufacturing concerns by regions:

Southeast	11,555
Southwest	791
Northeast	6,211
Middle States	4,857
Northwest	612
Far West	2,886
Total U. S.	26,912

Forest Survey statistics for 1937 show that there were 3,043 sawmills operating in North Carolina alone, more than in any other state

Table II. - Per capita personal income of farm and non-farm population and estimated true wealth, by states, with ranking of each[1]/

State or Region	Per capita income and ranking-1929[2]/						Estimated per capita true wealth, 1930	
	Entire population		Non-farm population		Farm population			
	Income	Ranking	Income	Ranking	Income	Ranking	Wealth	Ranking
Georgia	$ 343	43	$ 532	42	$ 147	45	$1,377	46
Kentucky	398	41	605	36	148	44	1,399	45
North Carolina	317	45	472	47	167	42	1,482	42
South Carolina	261	48	412	48	129	48	1,423	43
Tennessee	346	42	529	44	137	47	1,667	40
Virginia	431	38	594	38	182	40	2,081	34
West Virginia	485	35	602	37	157	43	2,775	27
Southeast	365	6	535	6	183	6		
Southwest	564	5	683	5	366	3&4		
Northeast	881	2	946	2	366	3&4		
Middle States	715	3	854	3	262	5		
Northwest	590	4	703	4	426	2		
Far West	921	1	953	1	818	1		

1/From Odum, "Southern Regions of the United States", University of North Carolina Press, Chapel Hill, N.C. 1936.

2/These figures estimated to be about 25 percent too high for 1939-40 conditions.

Table 12. - Average annual value added by manufacturing[1]/ (thousands of dollars)

	Ranking				
	1st	2nd	3rd	4th	5th
Georgia	75,079 (Clothing, textiles, knit goods)	22,759 (Wood products, turpentine and furniture)	6,833 (Iron and steel)	____	____
Kentucky	28,736 (Liquors distilled)	17,705 (Steel)	12,390 (Wood)	____	____
North Carolina	164,756 (Clothing)	100,481 (Tobacco products)	34,014 (Wood)	____	____
South Carolina	78,424 (Clothing)	11,262 (Wood)	2,783 (Fertilizers)	____	____
Tennessee	64,241 (Clothing)	27,962 (Wood)	18,592 (Steel)	____	____
Virginia	57,846 (Clothing)	50,793 (Tobacco products)	36,835 (Wood)	15,124 (Steel)	____
West Virginia	41,898 (Steel)	24,126 (Glass)	19,035 (Chemicals)	9,910 (Pottery, porcelain)	9,523 (Wood)

1/Based on 1935 Census of Agriculture.

in the country. North Carolina ranked first in the South in 1938 in lumber production and fourth in the United States.

There is a decreasing trend in cotton acreage in the Appalachian territory and a general reduction in the number of and acreage in farms (table 13). The decline in cotton growing has been a serious economic blow to the region. Cotton is the number one cash crop in Tennessee, Georgia, and South Carolina and is second only to tobacco in North Carolina. Depleted land, the boll weevil, high fertilizer costs, inroads of substitutes, and expansion of foreign culture, present a dreary outlook for future improvement in the cotton situation. Experts agree that the demand for cotton in this country will never regain its former position.

Thus, the cotton producer must turn to some other crop, profitable to grow, especially on marginal, depleted, or eroded areas that produce small cotton yields. In the other states where cotton is not grown or is an unimportant cash crop, a similar unprofitable condition exists on poor lands now being cultivated or pastured.

Importance of Timber Growing and Relation to Fire

The bright side to the agricultural situation in both cotton producing and non-cotton producing states in the territory of the Appalachian Station is the increasing importance of timber growing. These states have always ranked well in the nation's timber production. The production of lumber, lath, and shingles for 1938, table 14, shows that the Appalachian territory ranks high in the United States in sawed lumber. North Carolina, which rated eleventh in lumber sawed in 1936, stood fourth place two years later.

In the last three or four years the development of processes for making newsprint and other types of paper from southern pines has greatly increased the activities of pulp and paper companies in the South. This is particularly fortunate for the cotton-producing states because the increasing demand for pulpwood now, and the future supplies that new mills will require make it worth-while for the cotton producer to consider growing trees on some of his poorer land as one method of diversification. The small land owner or tenant in the huge Piedmont cotton-producing section now has an opportunity to cash in on a properly managed woodlot from time to time. The importance of this situation is brought out by figures 3 and 4. These show that most of the Piedmont is well forested but timber land is largely in small farm woodlots.

Figure 12 shows the location of pulp and paper mills, which have rapidly increased in number since 1936. The demands of these new mills will expand the market for pulpwood. In 1938 the South produced 3,528,734 cords of pulpwood or 38 percent of the national amount.

Table 13. - Change in number of farms and farm acreage, 1920 to 1930[1/]

State	Number farms	Acreage
	Percent change	Percent change
Georgia	-17.7	-13.2
Kentucky	-8.9	-7.8
North Carolina	3.7	-9.8
South Carolina	-18.0	-16.4
Tennessee	-2.8	-7.7
Virginia	-8.4	-9.9
West Virginia	-5.3	-8.0

1/ From "Fifteenth Census of the United States".

Table 14. - Production of lumber, lath, and shingles - 1938[1]/

State	Aggregate lumber sawed		Lath (Thousand)	Shingles (Squares)
	MM bd. ft.	Ranking		
Georgia	805	9	1,374	24,236
Kentucky	138	25	2,146	1,694
North Carolina	1,371	4	2,771	50,857
South Carolina	588	12	1,159	15,480
Tennessee	287	17	2,920	305
Virginia	512	14	9,227	13,352
West Virginia	217	20	5,384	----
Total for region	3,918	---	24,981	105,924
United States	21,646	---	583,777	6,319,236

1/From Bureau of Census report for forest products, November 1939.

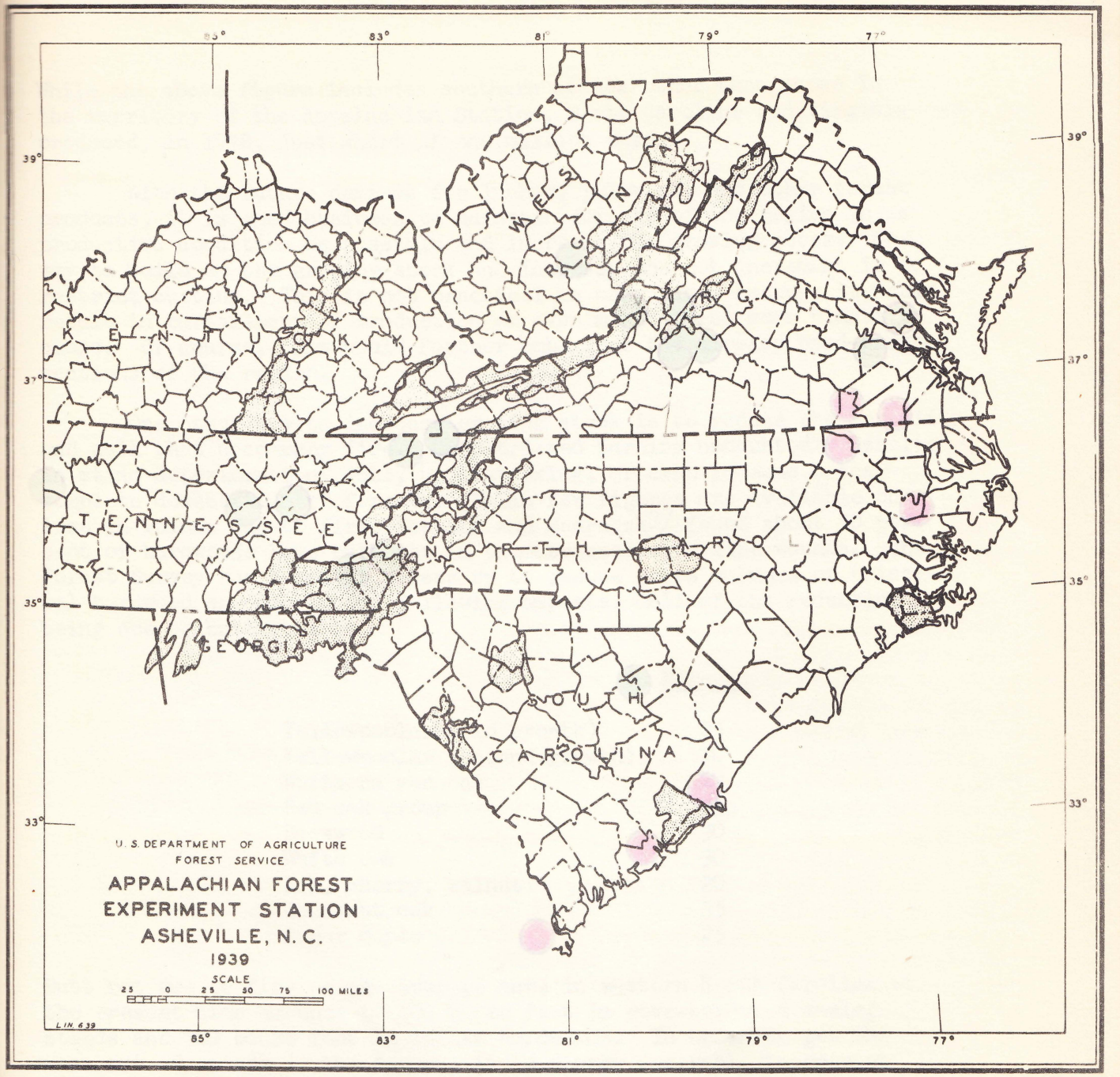


FIGURE 12.—PULP AND PAPER MILLS.

ESTABLISHED PRIOR TO 1936

ESTABLISHED 1936 TO 1939

While the above figure includes southern states other than those in the territory of the Appalachian Station, North Carolina and Virginia produced, in 1938, just short of one million cords.

With the future demands for lumber, pulpwood, and other forest products, it is good business to maintain forests of the region in as productive condition as possible and increase the growing stock. One way to build up the growing stock and increase the net increment is to restrict cutting. This is not practical in many cases because it would result in curtailment of production or even might force some plants to close. Of course, this would further embarrass the already hard-pressed sections of the region.

One other way to increase growing stock is to reduce the mortality and cull that accompany fire. Unrestricted burning undoubtedly results in stand deterioration, cull, understocking, or even in some cases, complete devastation of forests. While few figures are available on loss in volume due to fire, Hepting and Hedgcock3/ found about 50 percent of hardwoods have butt rot in them traceable to fire wounds. The Forest Survey has found it necessary to reduce gross volumes of principal hardwood species by the following amounts, half of the reduction being due to butt rot:

	Percent
Yellowpoplar (old growth)	25
Yellowpoplar (second growth)	10
Northern red oak	20
Red oak group	35
Basswood	30
White oak	30
Ash, cherry, walnut	20
Chestnut oak	35
Sugar maple	25

Butt rot due to fire on the average acre in western North Carolina at the present time amounts to 400 board feet in cove-hardwood sawlog stands and 320 board feet in upland hardwoods. In order to get the most out of stands in the future, it is highly desirable to prevent these fire losses to valuable butt logs.

Reliable hardwood mortality data indicate highly significant losses due to fire in lower diameters and above 6 inches for heavy and severe fires. The following figures show net mortality due to fire, based on records from 22 plots in Georgia, Tennessee, North Carolina, Virginia, and West Virginia:

3/ "Decay in merchantable oak, yellow poplar, and basswood in the Appalachian Region", by George H. Hepting and George G. Hedgcock. Tech. Bull. No. 570, 1937.

Severity of fire	Diameter breast high							
	1	2	3	4	5	6	7	8 or more
	Percent mortality							
Light	56	36	24	15	10	5	4	3
Moderate	83	60	44	33	24	17	11	6
Heavy	100	76	58	45	34	25	17	10
Severe	100	100	84	67	53	41	30	20

Ordinarily the mortality in pitch, shortleaf, and Virginia pine stands is less than for hardwoods unless the fire is severe enough to crown. A heavy fire in western North Carolina will kill about 60 percent of pure pine stands that average 4 to 6 inches in diameter.

It must be remembered that to cull and mortality losses should be added other damages, such as reduced rate of growth, site and stand deterioration, etc. For example, the Southern Station has found that diameter growth of longleaf pine saplings is reduced 20 percent and height growth 25 percent with uncontrolled annual burning. Another example, some burned-over spruce lands are so damaged that the land will be incapable of supporting tree growth. Thus, all effects of uncontrolled fire that occurs without protection seriously reduce net increment of hardwood and conifer forests in the region and affect the important forest products industries accordingly.

The cull due to fire wounding in hardwoods is deferred over a long period of time. This means that future generations will have to bear the damage. Also, as previously mentioned, mortality is primarily in the young age classes which predominate in all parts of the region. These two facts emphasize the significance of fire protection in a region so susceptible to fire damage.

Effect of Fire on Water Supply, Erosion, and Floods

Volumes have been written and little more needs to be said on the value of forests as watershed cover. It is well known that fire severely damages the protecting cover not only by killing trees but by destroying the spongy layer of litter that absorbs precipitation and prevents rapid run-off and by destroying humus and lessening porosity of the soil. Experiments in the southern Appalachians shows that the burning of litter under an old growth pine-hardwood forest resulted in surface storm flow averaging 10 times as great as that on adjacent unburned areas with differences as great as 32 times for single storms.

Olsheler[4] attributes the unprecedented Ohio River flood of 1937 to the fact that Kentucky and forests of other adjoining states had been severely burned for years. He emphasized that fire and not cutting was responsible.

A steady, pure water supply is important in the Appalachian region to towns and industries. Many cities in the mountains depend on forested watersheds for civic water supplies. For example, six towns in western North Carolina obtain their water from the slopes of the Pisgah National Forest. Fire bares the soil to washing and eroding with the result that water reservoirs are muddied and silted.

Numerous industrial plants have come to the southern Appalachians to take advantage of the steady supply of pure water that flows from well-protected national forests. One large rayon factory, a cigarette paper plant, other paper companies, and textile mills have located near these forested watersheds where adequate fire protection insures a good water supply in the future. The same holds true for many textile mills in the upper Piedmont country.

The Appalachian sub-regions of the Southeast are more favored than any other section of the United States as far as potential water power goes.[5] Abundant rainfall and topography result in a high stream flow and large fall. North Carolina, South Carolina, and Georgia rank third, fourth, and sixth in the United States in developed water power. Odum states that the Southeast alone could produce the full 16 million horse-power which was the whole nation's water power output in 1930.

It seems important, therefore, for the states in the region to protect the valuable asset that plentiful, pure water has been and will be in the future. Fire protection will insure satisfactory watershed cover if cutting is properly managed. Well protected watersheds should continue to draw industries to this section of the country.

Use of Woodlands for Grazing and Relation to Fire

Five million head of cattle worth $115,000,000 depend largely on forests for pasture in the Appalachian region. Particularly in the pine woods, forests are used for grazing to a large extent.

4/"Forests, fires, floods." Department of Conservation, Frankfort, Kentucky, 1938.

5/Odum, "Southern Regions of the U. S."

It has been shown 6/ that winter burning in the pine woods favors forage production but at the expense of establishment of longleaf pine. The entire subject of controlled burning versus grazing and timber growing is still controversial but indiscriminate burning is frowned upon by timber growers and many cattle men alike. Fire produces abundant browse in some hardwood stands but here, also, indiscriminate heavy burning is not desirable for grazing because of rapid deterioration of browse that results.

Fire and Wildlife and Recreation

Within 500 miles of the Southern Highlands region (Southern Appalachian Mountains from southwestern Virginia to northern Georgia) live 80,000,000 people -- two-thirds of the entire population of the United States. This distance, an easy two-day automobile trip, makes the potential use of the forests of the highlands tremendous. It is estimated that 1,000,000 persons visit western North Carolina each year and spend $25,000,000. Comparison with expenditures in other recreational regions indicates that the Southern Highlands may eventually realize $250,000,000 annually from tourists and vacationists.

While no-one believes that one small or even one large fire will drive away recreationists, it is quite evident that on the whole the wildlife and scenery that attract such people definitely suffer from destruction of forests by fire. Adequate protection is essential if full recreational possibilities of the region are realized.

SPECIFIC FIRE PROBLEMS AND STATUS OF PRESENT KNOWLEDGE

Prevention

In a region where 99 percent of all fires are man-caused, there can be little question but that fire prevention is the number one problem if successful fire protection is to be achieved.

Occurrence

First, we need to know the "who, why, where, and when" of the man-caused fire problem. In other words--

Who starts fires - what classes of people?
Why are fires started - because of malice, carelessness, thoughtlessness, accident, or intention?
Where are the problem areas - near towns, farms, range land, or elsewhere?
When are fires likely to occur, with what periodicity?

6/"Effects of fire and cattle grazing on longleaf pine lands as studied at McNeill, Mississippi", W. G. Wahlenberg, S. W. Greene, and H. R. Reed. U.S.D.A. Tech. Bull. No. 683, June, 1939.

Accumulation of fire statistics over past years has supplied excellent information - for protected areas - on the agencies that start fires, where the problem areas lie, and when the fires are most likely to concentrate. Meager data of questionable accuracy are available for unprotected areas, however, where the greatest numbers of fires occur. This is natural because no source of information exists in such sections.

Only in the past year or two has any serious attempt been made to learn the underlying causes of fires. We know that incendiaries, debris burners, smokers, and campers cause 74 percent of our fires, but we still are not sure why. Much prevention effort has been wasted in the past because it was not aimed in the right direction. Complete understanding of the psychological, social, and economic reasons behind man-caused fires is essential if we are to capitalize on what we have learned regarding fire occurrence. The administration organization of the federal Forest Service has barely made a start toward solving this problem. No organized effort at all has been made by state and private protective organizations.

Effects

After all details of fire occurrence are learned, one of the first things that must be known before an effective prevention campaign can be carried out is the effect of fire. We know, in general, that wild fires do damage in most places from most points of view. The nature of the damage and its extent has been largely a matter of conjecture, however. Consequently, prevention work has lost some of its forcefulness in generalities.

Fire effects data that are needed follow: tree mortality, effect on growth and quantity of all forest products, cull from decay due to wounding, stand composition, reproduction, quality of forest products, forage, run-off and erosion, fish and game, and recreation. At the present time we have partial information on mortality, growth, and cull relations with fire in most types. Some data are available in pine types regarding the effect of fire on grazing and reproduction. Specific data on virtually all other effects of fire are not available.

Damage appraisal

For an active prevention program to be most effective against carelessness, thoughtlessness, and maliciousness, we should know the dollars and cents damage caused by fire in each type. Particularly in hardwood stands are fire effects difficult to appraise because of the ability of hardwoods to sprout and cover up damages. Indirect or intangible effects also make the job of damage appraisal extremely complex.

Alsheler[4] attributes the unprecedented Ohio River flood of 1937 to the fact that Kentucky and forests of other adjoining states had been severely burned for years. He emphasized that fire and not cutting was responsible.

A steady, pure water supply is important in the Appalachian region to towns and industries. Many cities in the mountains depend on forested watersheds for civic water supplies. For example, six towns in western North Carolina obtain their water from the slopes of the Pisgah National Forest. Fire bares the soil to washing and eroding with the result that water reservoirs are muddied and silted.

Numerous industrial plants have come to the southern Appalachians to take advantage of the steady supply of pure water that flows from well-protected national forests. One large rayon factory, a cigarette paper plant, other paper companies, and textile mills have located near these forested watersheds where adequate fire protection insures a good water supply in the future. The same holds true for many textile mills in the upper Piedmont country.

The Appalachian sub-regions of the Southeast are more favored than any other section of the United States as far as potential water power goes.[5] Abundant rainfall and topography result in a high stream flow and large fall. North Carolina, South Carolina, and Georgia rank third, fourth, and sixth in the United States in developed water power. Odum states that the Southeast alone could produce the full 16 million horse-power which was the whole nation's water power output in 1930.

It seems important, therefore, for the states in the region to protect the valuable asset that plentiful, pure water has been and will be in the future. Fire protection will insure satisfactory watershed cover if cutting is properly managed. Well protected watersheds should continue to draw industries to this section of the country.

Use of Woodlands for Grazing and Relation to Fire

Five million head of cattle worth $115,000,000 depend largely on forests for pasture in the Appalachian region. Particularly in the pine woods, forests are used for grazing to a large extent.

4/"Forests, fires, floods." Department of Conservation, Frankfort, Kentucky, 1938.

5/Odum, "Southern Regions of the U. S."

It has been shown 6/ that winter burning in the pine woods favors forage production but at the expense of establishment of longleaf pine. The entire subject of controlled burning versus grazing and timber growing is still controversial but indiscriminate burning is frowned upon by timber growers and many cattle men alike. Fire produces abundant browse in some hardwood stands but here, also, indiscriminate heavy burning is not desirable for grazing because of rapid deterioration of browse that results.

Fire and Wildlife and Recreation

Within 500 miles of the Southern Highlands region (Southern Appalachian Mountains from southwestern Virginia to northern Georgia) live 80,000,000 people -- two-thirds of the entire population of the United States. This distance, an easy two-day automobile trip, makes the potential use of the forests of the highlands tremendous. It is estimated that 1,000,000 persons visit western North Carolina each year and spend $25,000,000. Comparison with expenditures in other recreational regions indicates that the Southern Highlands may eventually realize $250,000,000 annually from tourists and vacationists.

While no-one believes that one small or even one large fire will drive away recreationists, it is quite evident that on the whole the wildlife and scenery that attract such people definitely suffer from destruction of forests by fire. Adequate protection is essential if full recreational possibilities of the region are realized.

SPECIFIC FIRE PROBLEMS AND STATUS OF PRESENT KNOWLEDGE

Prevention

In a region where 99 percent of all fires are man-caused, there can be little question but that fire prevention is the number one problem if successful fire protection is to be achieved.

Occurrence

First, we need to know the "who, why, where, and when" of the man-caused fire problem. In other words--

Who starts fires - what classes of people?
Why are fires started - because of malice, carelessness, thoughtlessness, accident, or intention?
Where are the problem areas - near towns, farms, range land, or elsewhere?
When are fires likely to occur, with what periodicity?

6/"Effects of fire and cattle grazing on longleaf pine lands as studied at McNeill, Mississippi", W. G. Wahlenberg, S. W. Greene, and H. R. Reed. U.S.D.A. Tech. Bull. No. 683, June, 1939.

Accumulation of fire statistics over past years has supplied excellent information - for protected areas - on the agencies that start fires, where the problem areas lie, and when the fires are most likely to concentrate. Meager data of questionable accuracy are available for unprotected areas, however, where the greatest numbers of fires occur. This is natural because no source of information exists in such sections.

Only in the past year or two has any serious attempt been made to learn the underlying causes of fires. We know that incendiaries, debris burners, smokers, and campers cause 74 percent of our fires, but we still are not sure why. Much prevention effort has been wasted in the past because it was not aimed in the right direction. Complete understanding of the psychological, social, and economic reasons behind man-caused fires is essential if we are to capitalize on what we have learned regarding fire occurrence. The administration organization of the federal Forest Service has barely made a start toward solving this problem. No organized effort at all has been made by state and private protective organizations.

Effects

After all details of fire occurrence are learned, one of the first things that must be known before an effective prevention campaign can be carried out is the effect of fire. We know, in general, that wild fires do damage in most places from most points of view. The nature of the damage and its extent has been largely a matter of conjecture, however. Consequently, prevention work has lost some of its forcefulness in generalities.

Fire effects data that are needed follow: tree mortality, effect on growth and quantity of all forest products, cull from decay due to wounding, stand composition, reproduction, quality of forest products, forage, run-off and erosion, fish and game, and recreation. At the present time we have partial information on mortality, growth, and cull relations with fire in most types. Some data are available in pine types regarding the effect of fire on grazing and reproduction. Specific data on virtually all other effects of fire are not available.

Damage appraisal

For an active prevention program to be most effective against carelessness, thoughtlessness, and maliciousness, we should know the dollars and cents damage caused by fire in each type. Particularly in hardwood stands are fire effects difficult to appraise because of the ability of hardwoods to sprout and cover up damages. Indirect or intangible effects also make the job of damage appraisal extremely complex.

Figure 13. - Cut-over, burned-over, spruce type in North Carolina. The evaluation of such an effect of fire on site is a major problem that the Station has not yet undertaken.

Figure 14.- Young hardwood stand completely killed by fire. Although such trees have no present commercial value, their destruction seriously delays future returns to the land owner. The Station is developing appraisal methods for such damage but the job is not yet completed.

Figure 15.- A valuable butt log culled because of decay that entered through a fire wound. Inasmuch as the decaying process takes place over many years and because the tree heals over the fire scar as shown above, determination of probable future cull due to fire is difficult. The Station is working on this problem.

At the present time some exploratory work has been done by this Station in the development of appraisal techniques for mortality and cull in hardwood types. One of the most important jobs yet to be done is to develop methods of appraising intangible fire effects, for in many cases these are much more significant than the effects of fire on timber growth.

Prevention methods

Determination of the best methods and techniques of fire prevention is the action phase of this job that cannot be completed in final form until adequate information on occurrence, fire effects and damage appraisal has been compiled. A great deal can be accomplished, however, by the development of sound methods of approach to specific problems already discovered. Surveys and analyses of accomplishments by different methods of law enforcement, legislation, personal contact, lecture, posters and exhibits, literature, and other means should be made. In many cases techniques for evaluating the degree of success or failure must be derived.

Finally, a very important phase of this problem is the evaluation of results of prevention versus their costs. Specific techniques need to be developed to make such comparisons valid for their results are often influenced by other factors which cannot be controlled, such as severity of each fire season.

Summary of the prevention problems in order of priority

The reduction of man-caused fires - number one problem in the region - can be accomplished to a satisfactory degree only after the jobs listed in table 15 are near completion. This table shows that of the nine phases of the prevention problem, the first three are now being well handled by the State forestry organization in cooperation with the U. S. Forest Service, Division of State and Private Forestry. Present knowledge is meager on four of the remaining six phases and fair on the other two. The six phases of the prevention problem on which further research is needed entirely or in part by the Appalachian Forest Experiment Station are assigned numbers in table 15 in order of their priority.

Fire Control

While reduction in number of man-caused fires is without doubt the number one problem in the region, considerable advances can yet be made in fire control. Many fire protection agencies in the region are doing splendid prevention work but due to their financial limitations and the time required to conquer the man-caused fire problem, they are at present confronted with a huge task of current fire suppression.

Table 15.-Summary of prevention problems and status of knowledge.

Phase	Status of knowledge	Agencies working on problem	Action needed	Priority rating
Who starts fires.	Good	U.S.F.S. Administration, State foresters.	Continue as at present.	
Where are problem areas.	Good	U.S.F.S. Administration, State foresters.	Continue as at present.	
When do fires occur.	Good	U.S.F.S. Administration, State foresters.	Continue as at present.	
Why are fires started--underlying causes of occurrence.	Meager	U.S.F.S. Administration.	Expanded research by Appalachian For. Exp. Sta.	1
Determination of intangible fire effects.	Meager	U.S.F.S. Administration, U.S.Biological Survey, Privately endowed research in game management-Stoddard.	Expanded research by Appalachian For. Exp. Sta., U.S.Biological Survey, Universities.	2
Determination of tangible fire effects on mortality, cull and growth.	Fair	Appalachian For. Exp. Sta.	Continued research by Appalachian For. Exp. Sta.	3
Development of damage appraisal methods for tangible values.	Fair	Appalachian For. Exp. Sta.	Continued research by Appalachian For. Exp. Sta.	4
Development of damage appraisal methods for intangibles.	Meager	U.S.F.S. Administration, State foresters.	Expanded research by Appalachian For. Exp. Sta., National Park Service, game specialists.	5
Development of effective methods of applying prevention methods and evaluation of accomplishments.	Meager	U.S.F.S. Administration, State foresters.	Expanded research by Appalachian For. Exp. Sta.	6

Obviously, all effort cannot be placed on prevention while the forests burn unchecked.

Presuppression

Some of the best chances for saving fire control dollars lie in making better and more efficient use of available presuppression facilities. If a fire protectionist were clairsentient and a sage as well, he would always be able to have exactly the right number of men at every spot a fire was going to occur. Presuppression and suppression costs would thus be reduced to an absolute minimum. Lacking such powers, the official responsible for fire control can do one of three things: (1) have a man "behind every tree", (2) have no men until a fire starts, or (3) attempt to strike a happy medium between the first two possibilities. The first would obviously be too expensive. The second would undoubtedly result in huge burned acreage because of lack of preparedness. Efficiency of fire control can be measured by the degree of success with which an administrator chooses the point of diminishing returns represented in the third possibility - the point where further expenditures fail to eliminate an equal amount of damage. The degree of presuppression effort should be aimed at this point of diminishing returns.

Fire control planning that has been carried on by many federal agencies in the past has for its major objective the determination of presuppression needs. Briefly, fire plans should show the most efficient detection system, communication facilities, transportation in the form of roads and trails, and man power required. All of these are determined from an inventory of fire occurrence, character of fuels as influencing the size of the fire control job, and values at stake. These basic factors, when properly analyzed and integrated, tell where towers, phone lines, roads, and man power are needed, and how many or how much are required. Measurements of existing fuel and weather conditions, on the other hand, are needed to tell when the above facilities are required. If such determinations are properly made and executed, the fire control officer can come close to obtaining the best presuppression, consequently the best suppression, possible.

Presuppression planning, or determination of ways to improve the use of available facilities is the number two job in importance in the region. Progress has been made by both administration and research on this joint undertaking.

Danger measurements.-The measurement of fluctuating fuel and atmospheric conditions, integrated and expressed on a numerical scale, serves as an excellent guide to the placement of presuppression man power. Danger ratings indicate when facilities should be made available. The Station has already done considerable work on finding what

elements to measure, how to measure them, and how to integrate the measurements. A wide-scale test of two danger measuring systems is under way in the mountains and the Coastal Plain. The systems have not yet been perfected. Little is known about where to measure danger and what differences to expect from valley to mountain top on different aspects. The small amount of work that has been done on this phase of danger measurement emphasizes its importance and the desirability of continuing such study.

At the Bent Creek Experimental Forest, six fire-weather stations were operated during the past year, located in pairs at different elevations (500 vertical feet apart), one of each pair being on a northwest- and the other on a southeast-facing slope. The "low" station and "middle" slope station on the northwest slope compared as follows during November 1939:

	November					
	14	15	16	17	18	Mean
Maximum temperature						
Low station	65	69	65	68	62	66
Middle station	60	64	62	66	61	63
Minimum temperature						
Low station	21	23	27	29	35	27
Middle station	41	43	47	48	50	45
Maximum relative humidity						
Low station	100	100	96	94	87	96
Middle station	32	35	33	32	33	33
Minimum relative humidity						
Low station	19	17	21	15	33	21
Middle station	23	21	24	17	27	22

The extreme differences brought about by exposure illustrate the importance of measuring danger in the proper place, something we know little about at present. An 18-degree difference in average minimum temperature for the period and 65 percent differences in night-time humidities certainly resulted in more favorable fuel moistures on the lower slopes and in the valleys.

The present method of indicating cumulative drying by "days since 0.50 inches of rain" is unsatisfactory. Research to develop improved techniques is extremely desirable.

One important value of danger measurements is in rating character of fire seasons to compare or judge efficiency of fire control organiza-

Figure 16.-A typical fire danger station. The system of measuring danger has been fairly well determined. Refinements need to be made and most important, we know little about where such stations should be located to sample the forest properly.

tions. Techniques for making such comparisons are not now available. Organization requirements for each danger class cannot be determined until accurate information is available on rates of spread by fuel types. This is a research job and one that very little has been done about.

The whole subject of danger measurement, one of the studies that offers most promise of increasing presuppression efficiency, is fairly well along. However, considerably more refinement can be made in danger rating systems and new techniques for applying and utilizing the systems to the best advantage need to be developed.

Man power and equipment requirements.-Correct determination of man power and equipment needed in each fire protection unit and their distribution spell the success of the fire control job. The administrative organization has properly taken the lead in studies of such requirements and has based conclusions on investigations of normal occurrence, normal fire danger, fuel types, and values at stake. There is still much to be done in studying rates of spread of fire and its resistance to control in different fuel types. Rate of spread studies, to be properly worked out, should include fundamental studies of fire behavior as influenced by inflammability and wind. Determination of methods and techniques for judging potential damage of areas is a job for research that has barely been started.

Detection planning.- The Station has made a major contribution in recent years by evolving a technique of planning a lookout system. This included the development of seen-area mapping techniques and point value determination. Studies of visibility distance followed the invention of haze meters and these have been completed. Certain refinements yet need to be worked out to improve the efficiency of detection systems, however. No one knows the relative merits of fixed versus moving detectors. Certain refinements in manning lookout station networks could be made if information were available on the relation of fuel condition to volume of smoke produced. The relative visibility of smokes within the visual range has never been studied. These are all jobs for research.

Communication and transportation planning.-Administration is better equipped to plan communication and transportation facilities than the research branch, for these subjects involve engineering principles and practices. Communication and transportation needs, however, should be based on fundamental inventories of occurrence, fuels, and values.

Personnel training.- Most glaring failures in suppression can be traced to inadequate personnel training. In spite of emphasis on this

Hardwood litter fuel type.

Cut-over spruce fuel type.

Figure 17.-Characteristics of fire behavior must be determined for 14 fuel types as different as those shown above.

phase of presuppression, much progress can undoubtedly be made by better training methods. Development of such methods should be a joint administrative-research undertaking.

Suppression

Investigations dealing with fire suppression can most logically be divided into three groups: (1) strategy and tactics, (2) crew organization factors, and (3) tools, equipment, and chemicals.

Strategy and tactics.-In this region there is considerable room for improving strategy of attack on fires and developing tactics that best suit a variety of occasions. The nature of the problems dictates that they should be solved by administration but research must supply the basic information on fire behavior. The investigation required to produce this information would include consideration of the physics of combustion, and fundamental fire behavior.

Organization.-Administration is probably best able to conduct organization studies and has largely taken the lead in the past. We need to know what sizes of crews are most efficient in handling fast-spreading fires common in the region. What is the best organization of these crews? Hold line output is outstandingly low for the most part. What organization changes are needed to speed up production? Studies of physical limitations and fatigue need to be made. Research can and should help in studying the factors that contribute to inefficient crew action.

Tools, equipment, and chemicals.-The present knowledge and development of tools and equipment is far ahead of the practice and use of them. Consequently, low priority should be given to such work in the near future. The research organization has few personnel or physical facilities for development or adaptation of new hand tools or power equipment, such as pumps, line building machinery, tankers, trucks, and airplanes. The use of chemicals as fire extinguishers has been well investigated in recent years and there appears to be little need for additional work in this line in the Appalachian region. The Station should, however, continue, as in the past, to test and check new developments from outside the region.

Economics

The economics of fire control is really not a separate problem but is tied in with every phase of the fire control job and is so important that it deserves more than passing attention. Economic considerations enter into fire control plans of all kinds; the determination of detection network, man power requirements, and road and trail needs. If fire control is planned for on a sound business basis, then an economic objective must be set up. It resolves itself into a

cost-accounting study (in the broadest sense), a job of finding the most profitable expenditure. As such it involves every phase of fire protection, particularly presuppression. This will constitute a major job for research in the future.

At the present time practically nothing is known of the place of forest fire insurance in the region. There is nothing to indicate that development of standards and recommendation for fire insurance should stand very high on the scale of priorities. Insurance studies, however, will be a future responsibility of the research organization.

Summary of fire control problems in order of priority

Of the 15 fire control problems listed in table 16, knowledge is classified as good on three, fair on five, meager on six, and there is nothing known on one. All but one of the 15 problems should be considered in the research program of the Appalachian Station; the one not being considered is sufficiently well handled by the administrative organization. The remaining 14 problems have been assigned priorities in table 16.

Use of Controlled Fire

The values attached to the use of controlled fire have been debated for years, for the entire subject of controlled burning is highly complex. In the past, most agencies responsible for the control of wild fires have opposed any use of fire on the grounds that all fire is bad. The success of fire prevention campaigns depended, they would reason, on selling this idea to the people because the layman could not appreciate the difference between a controlled fire and a wild one. While there is some merit to this attitude, it has become increasingly apparent that fire does have a place in good forest management. At the same time it has become evident that determination of the value of controlled burning is extremely complex if all its effects are weighed. Thus, the number three problem in the region centers around the use of fire.

Desirability of controlled burning in Coastal Plain

There is a greater opportunity to utilize fire in forest management in the Coastal Plain than in other parts of the region. Considerable progress has been made in the deep South on certain phases of controlled burning but for the Coastal Plain in the Appalachian Station's territory, data are fragmentary. Of course, generalizations from work elsewhere may be made for the Carolinas where types and sites are similar. On the whole, however, the desirability of burning in these pinewoods is debatable.

Table 16.-Summary of fire control problems and status of knowledge.

Phase	Status of knowledge	Agencies working on problem	Action needed	Priority rating
Fundamental studies of fire behavior as background for determining man power and equipment needs.	Meager	None	Expanded research by Appalachian For. Exp. Sta.	1
Fundamental studies of inflammability for same use as directly above.	Meager	Appalachian For. Exp. Sta.	Expanded research by Appalachian For. Exp. Sta.	2
Improvement of danger measurement systems including determination of what, how, and where to measure.	Fair	U. S. F. S. Administration, Appalachian For. Exp. Sta.	Continue as at present.	3
Development of methods of applying danger ratings to fire control.	Meager	U.S.F.S. Administration, Appalachian For. Exp. Sta. (very limited).	Expanded research by Appalachian For. Exp. Sta.	4
Determination of the economic fire control objectives.	Meager	None	Expanded research by Appalachian For. Exp. Sta.	5
Theory of visibility measurement.	Good	Appalachian For. Exp. Sta.	Continue as at present.	6
Fuel type studies of rate of spread and resistance to control.	Fair	U.S.F.S. Administration, Appalachian For. Exp. Sta.	Continue as at present.	7

Table 16.-Summary of fire control problems and status of knowledge (Cont'd).

Phase	Status of knowledge	Agencies working on problem	Action needed	Priority rating
Fundamental studies of ignition and combustion.	Meager	None	Expanded research by Appalachian For. Exp. Sta.	8
Detection studies.	Good	Appalachian For. Exp. Sta.	Continue as at present.	9
Determination of physical limitations and fatigue factors as affecting organization.	Meager	Appalachian For. Exp. Sta.	Continue with additional research by Appalachian For. Exp. Sta.	10
Development of strategy and tactics of fire suppression.	Fair	U.S.F.S. Administration	Expanded research by Appalachian For. Exp. Sta.	11
Determination of place of forest fire insurance and evaluation of standards and recommendations for its use.	None	None	Expanded research by Appalachian For. Exp. Sta. in future.	12
Development of methods of testing tools, equipment, and chemicals.	Fair	U.S.F.S. Administration, Appalachian For. Exp. Sta.	Continue as at present.	13
Development of fire training methods.	Fair	U.S.F.S. Administration.	Expanded research by Appalachian For. Exp. Sta.	14
Development of transportation and communication plans.	Good	U.S.F.S. Administration.	Continue as at present.	

Silviculture.-One of the most serious problems that confronts timber growers in the Coastal Plain who have excluded fire for a number of years, is the gradual change from pine toward the hardwood climax. Repeated burning or cutting is necessary to keep down scrub oak and other undesirable hardwoods. Longleaf pine is a fire type and cannot be maintained without some burning or expensive hardwood sanitation measures. Loblolly pine types, particularly when cut selectively, rapidly move toward a hardwood climax if fire is kept out. There is the possibility that controlled fire might be used to improve the stocking of dense stands of pine. The effect of annual or periodic burning on growth rate and quality of pine needs to be determined. It is possible that burning may not influence growth but may increase the value of sawtimber because of early pruning of lower branches by fire. Or, pitch streaks may result from the heat of fires and lower the quality of the product. All of these are important questions that complicate the problem and make it an important research job.

Hazard reduction.-Controlled fires reduce fuel volume and tend to prevent high damage by intense accidental fires burning in an accumulation of litter. The value of controlled fire for hazard reduction purposes centers around two things: (1) does the slight annual damage associated with repeated light burning equal or exceed (per protection unit) the damage from a single accidental fire? (2) what are the relative costs of controlled burning versus satisfactory protection? The Station has two sets of plots in South Carolina where data on the first question are being obtained. These plots are small, types are not well represented, and they are entirely inadequate to yield adequate results applicable to all parts of the Coastal Plain. Costs of burning versus exclusion of fire can best be determined by the administrative organization and require burning on a large scale. Data obtained in other regions should apply quite well in this section.

Wildlife management.-In the Coastal Plain, turkey, quail, and deer production is increasing so rapidly in importance that it bids to be one of the first considerations in multiple use of forest land. Large hunting estates are common in this section and the owners are primarily interested in managing their woods to produce game birds and animals. Stoddard has done considerable work in southern Georgia and finds controlled fire beneficial to turkey and quail. The economic principles of game versus timber production have not been determined and are important to many agencies, however. The use of fire in loblolly types and the effect on game birds and animals have not been studied. This is a major type in the Carolina flatwoods. The use of fire to maintain abundant hardwood sprouts for deer browse in the Coastal Plain needs considerable study.

Pest control.-Fire protectionists have argued for years, with little or no evidence, that fires do not materially influence pest populations. Nevertheless, woods burning for the purpose of pest control

Figure 18.--An outstanding fire research problem is to find how such heavy litter accumulations can be removed by fire without injuring young pine severely and at the same time prevent establishment of more tolerant undesirable hardwoods.

has been one of the chief sources of forest destruction due to wild fires in the past. It would seem desirable to determine if controlled fires affect numbers of ticks, boll-weevils, chiggers, snakes, and numerous other pests. The prevalence of pests affects other forest or farm activities. For example, epidemics of screw-worms in deer may be due to excessive tick infestation. Cotton farmers have long claimed that boll-weevils are bad when adjoining woods are unburned. Fragmentary data are available on all of these questions. They are research jobs but require biologists or entomologists for their proper execution. Since fire is thought to be the best pest control agent, research along these lines should probably be conducted jointly by the interested departments.

Other considerations.-Numerous other problems must be considered before the value of controlled burning in the Coastal Plain can be determined, but they are relatively unimportant and require mention only. The influence of fire on grazing has largely been determined. Burning at proper seasons is worth-while according to studies conducted in the deep South. The validity of such observations needs to be checked in the Appalachian types. Also, the effect of burned-area grazing on the quality of meat produced, a phase of the problem not yet investigated, should be studied.

It has been definitely shown that brownspot needle disease can be reduced by periodic burning in the deep South. In general, this disease is unimportant in the territory of the Appalachian Station. Thus, little work is needed on fire and its effect on brownspot. Other tree diseases that are influenced by fire are relatively unimportant.

The effect of fire on water supply is probably so unimportant in the flatwoods that no special investigations are necessary. There is a possibility that repeated burning may result in soil puddling and infiltration would be retarded. Changes in subsoil moisture might conceivably affect tree growth. Such effects would be revealed in tree growth studies and a special investigation of repeated burning on water supply is unwarranted.

Desirability of controlled burning in Piedmont and mountain regions

Many of the problems regarding the use of fire described for the Coastal Plain apply as well to the Piedmont and mountain regions.

Silviculture.-The greatest chances for applying fire as a tool in mountain or Piedmont silviculture seem to be in the hardwood types. We have made some observations on the value of fire in seedbed preparation. For example, yellowpoplar seed germinates profusely on burned areas compared with unburned. Other species may do likewise. There are fragmentary data to indicate that fire may be useful in coppice

Figure 19.-Heavy laurel and rhododendron understory which young, desirable hardwoods find difficult to penetrate.

regeneration because a greater proportion of desirable low sprouts results from burning. The value of fire in controlling stand density is yet undetermined. It may prove useful in converting undesirable types such as laurel and rhododendron slicks to valuable timber stands or at least to plantable sites. All of the above determinations are the responsibility of the research organization.

Hazard reduction.- Generally speaking, hazard reduction in these areas is relatively unimportant. Removal of litter by periodic burning is definitely undesirable in hardwood types where fuel accumulation never presents a serious problem.

Other considerations.-The value of controlled burning to wildlife management in Piedmont and mountain regions is not as evident as in the Coastal Plain. There is a need for investigations to determine how fire influences the food supply of deer in these areas. If periodic burning was found desirable in the mountains or the Piedmont, the effect on water relations would have to be studied. The possibility of excessive run-off or erosion following fire might be great. Virtually nothing is known of light burning and grazing effects. The determination of relative cost and benefits of all intention burning constitutes a major research problem.

Controlled burning techniques

Not only is it important to know that controlled burning is suitable treatment for a given area, but it is essential to understand exactly how to fire the area to produce the desired benefit. This obviously requires a complete knowledge of when to burn and the techniques involved.

A few individuals have learned by experience how to fire areas to produce the speed and intensity of fire desired. Usually they follow rules-of-thumb and have no scientifically-sound method of measuring the factors or imparting to others the exact technique involved. If the most is to be obtained from use of fire, studies are needed to evolve methods of determining when and how to burn to produce desired results.

Summary of problems regarding use of fire

Eight problems relating to the use of fire have been summarized in table 17 and the status of knowledge shown. Four problems rate as meager, four as fair in regard to present knowledge. All problems are considered as requiring a place in the Station's fire research program although three of them would be in cooperation with other agencies. Priorities are shown for the eight problems.

Table 17.-Summary of problems in use of fire and status of knowledge.

Phase	Status of knowledge	Agencies working on problem	Action needed	Priority rating
Determination of silvicultural value of fire in mountains and Piedmont.	Meager	Appalachian For. Exp. Sta. (very limited)	Expanded research by Appalachian For. Exp. Sta.	1
Determination of when and how to use fire in mountain and Piedmont silviculture.	Meager	None	Expanded research by Appalachian For. Exp. Sta.	2
Determination of desirability of controlled burning in Coastal Plain silviculture.	Fair	Southern Forest Exp. Sta.	Continue as at present with expanded research by Appalachian For. Exp. Sta.	3
Determination of desirability of controlled burning in Coastal Plain hazard reduction.	Fair	Southern Forest Exp. Sta., U.S.F.S. Administration, Private companies.	Continue as at present with expanded research by Appalachian For. Exp. Sta.	4
Determination of when and how to use fire on Coastal Plain in silviculture and hazard reduction.	Fair	Southern Forest Exp. Sta., U.S.F.S. Administration, Private companies.	Continue as at present with expanded research by Appalachian For. Exp. Sta.	5
Determination of how fire can be used in wildlife management in the Coastal Plain, mountains, and Piedmont.	Meager	U.S.F.S. Administration, Privately endowed research.	Continue with expanded cooperative research by Appalachian For. Exp. Sta. and Biological Survey.	6
Determination of value of controlled fire in pest and disease control.	Meager	None active	Expanded cooperative research by Appalachian For. Exp. Sta., Bureau of Entomology, Bureau of Plant Industry and Biological Survey.	7

Table 17.-Summary of problems in use of fire and status of knowledge (Cont'd).

Phase	Status of knowledge	Agencies working on problem	Action	Priority rating
Effect of controlled fire on grazing in mountains, Piedmont and Coastal Plain.	Fair	Bureau of Animal Industry	Expanded cooperative research by Appalachian For. Exp. Sta. and Bureau of Animal Industry.	8

THE STATION'S FIRE RESEARCH PROGRAM

The three major fire problems -- prevention, control, and use of fire -- can be solved only after a study is completed of each phase for which present knowledge is unsatisfactory. Such phases have already been determined in the preceding section where they were listed in order of priority.

In planning a fire research program for the Station there are certain considerations other than the relative importance of specific jobs to be done. For example, other agencies may have work under way that will completely or partially solve our problems. Also, the facilities available for work on a problem may be inadequate, or personnel may be unable to handle given high priority jobs as they should be handled. Finally, personnel may have special training in fields that fit them to work on low priority jobs rather than studies of more current interest, and because of such capabilities may be able to produce much of country-wide value although little for solving important local problems. As priorities are bound to change in the future, there seems to be little use in planning ahead much farther than five years.

List of Studies

A complete summary of all fire studies needed, in order of their priority, their status on the present fire research program, and justification for this position has been presented in table 18.

The Current Fire Research Program

The current program that results from the tabulation in table 18 is for the present fire research staff of three men, one each in P-1, P-2, and P-4, grades.

Studies now under way to be completed within next five years

1. Determination of effect of fire on mortality, growth and cull (1944).
2. Appraisal of these effects (1944).
3. Theory of visibility measurement (1942).
4. Fuel type studies of rate of spread (1942).

Studies now under way but not to be completed within next five years

1. Fundamental studies of inflammability.
2. Improvement of danger measuring systems, including a determination of what, how, and where to measure.

Table 18.-Fire studies needed, in order of priority, and status under present program.

Priority rating	Study	Status on present research program	Reason why study is not on present program -- remarks
1	Determination of underlying causes of fire occurrence.	None	Lack trained personnel
2	Determination of intangible fire effects.	To be started in 1942.	
3	Determination of tangible fire effects on mortality, growth, and cull.	Under way - to be completed in 1944.	
4	Development of damage appraisal methods for tangibles.	Under way - to be completed in 1944.	
5	Development of damage appraisal methods for intangibles.	None	Study 2 must be started first. Basic statistics need summarization. Will require parallel work by recreationists and game specialists. Also influences experts.
6	Development of effective methods of applying prevention methods and evaluation of accomplishments.	None	Study 1 must be well along and some results from others above must be available before study 6 can be started. Will require much cooperation by administrative agencies.
7	Fundamental studies of fire behavior as a background for determining man power and equipment needs.	None	Cannot work on this unless other partially completed studies are dropped.
8	Fundamental studies of inflammability.	Some theoretical work under way.	Have qualified personnel but other studies would have to be dropped to initiate extensive new work in this phase.

Table 18.-Fire studies needed, in order of priority, and status under present program (Cont'd).

Priority rating	Study	Status on present research program	Reason why study is not on present program -- remarks
9	Improvement of danger measurement system, including determination of what, how, and where to measure.	Now under way.	
10	Development of methods for applying danger ratings to fire control.	Very limited work.	Should be working more actively on this but would have to drop other partially completed studies.
11	Determination of the economic fire control objectives.	Start planned for 1943.	Data from studies, 2, 3, 4, and 5 required before this can be completed but should start work soon.
12	Theory of visibility measurement.	Work under way - to be completed by 1942.	
13	Determination of silvicultural value of fire in mountains.	None	Insufficient personnel available.
14	Determination of when and how to use fire in mountain silviculture.	None	Insufficient personnel available.
15	Determination of desirability of controlled burning in coastal plain silviculture.	None	Insufficient personnel now. Southern Station is working on this but not in our most important types.
16	Determination of desirability of controlled burning in coastal plain hazard reduction.	None	Insufficient personnel now. Southern Station is working on this but not in our most important types.
17	Determination of when and how to use fire on coastal plain in silviculture and hazard reduction.	None	Insufficient personnel now. Southern Station is working on this but not in our most important types.

Table 18.-Fire studies needed, in order of priority, and status under present program (Cont'd).

Priority rating	Study	Status on present research program	Reason why study is not on present program - remarks
18	Determination of how fire can be used in wildlife management in Coastal Plain and mountains.	None	Lack trained personnel.
19	Fuel type studies of rate of spread and resistance to control.	Now under way — complete by 1942.	
20	Fundamental studies of ignition and combustion.	Will start in 1943.	
21	Detection studies.	None	Have made good progress already. Further work less important than other studies listed.
22	Determination of physical limitations and fatigue factors as affecting organization.	None	Inadequate personnel.
23	Development of strategy and tactics of suppression.	None	Inadequate personnel.
24	Determination of place of forest fire insurance and evaluation of standards and recommendations for its use.	None	Low in priority and inadequate personnel.
25	Development of methods of testing tools, chemicals, and equipment.	None	Inadequate personnel.
26	Determination of the value of controlled fire in pest & disease control.	None	Inadequate personnel. Would involve highly cooperative work with Bureau of Entomology, Bureau of Plant Industry, Biological Survey, etc.

Table 18.-Fire studies needed, in order of priority, and status under present program (Cont'd).

Priority rating	Study	Status on present research program	Reason why study is not on present program -- remarks
27	Determination of the effect of controlled fire on grazing in mountains, Piedmont, and Coastal Plain.	None	Lack of trained personnel. Low in priority. A cooperative job with the Bureau of Animal Industry.
28	Development of fire training methods.	None	Insufficient personnel for such a low priority job.

New studies to be started in next five years

1. Determination of intangible fire effects (1942).
2. Determination of economic fire control objectives (1943).
3. Fundamental studies of ignition and combustion (1943).

Considering the present personnel and the status of existing studies, there seems to be little choice but to continue all studies now under way. For instance, it would be unwise to drop any of the investigations listed in the first two categories above.

The choice of the three new studies was determined by a combination of considerations -- status of present work, relative priority of jobs, and training and ability of present personnel. A study of intangible fire effects is the second study on the priority list and fits in well with other fire effects studies that have been under way for some time. Determination of the economic fire control objectives, slated for 1943, ties in particularly well with certain phases of danger rating, fire control planning, and damage appraisal studies that have been under way in recent years. Finally, fundamental studies of ignition and combustion, which are important national research problems, though not high on the list of priorities for this region, can be handled at this station better than elsewhere or better than some other studies here because of personnel.

Substantial progress can be made on the five-year program listed, with present personnel, if annual allotments average $12,000 to $14,000. If allotments continue in the neighborhood of $10,000, as for Fiscal Year 1941, accomplishments will necessarily be somewhat slower on the new work to be started.

An Expanded Fire Research Program

The above list shows that of the 28 studies, presented in table 18, only six are being worked on at present, four of these will probably be completed within five years, and three new studies will be started in the same period. Only two of the ten studies with highest priority will be finished and work will be under way on three others. This leaves half of them unscheduled for at least five years unless some provision is made to enlarge the present staff.

The program and personnel

Work could be started on the five unscheduled studies of highest priority with the addition of two men, one a forester-economist, the other a forester with some training in psychology and sociology, in the P-3 and the P-2 grades, respectively.

The importance of certain phases of the use-of-fire problem, particularly the use of fire in mountain silviculture (on which very

little is being done), is so outstanding and there is such a pressing need for information on the subject that some work should be started. A forester in the P-2 grade would be needed to carry such studies.

Determination and appraisal of intangible fire effects, as well as lower priority studies connected with use of fire in wildlife management and effect on pests, suggest the need of a cooperating biologist at the Station. Important contributions could be made by such a man working with fire project members on various phases of the expanded fire effects program.

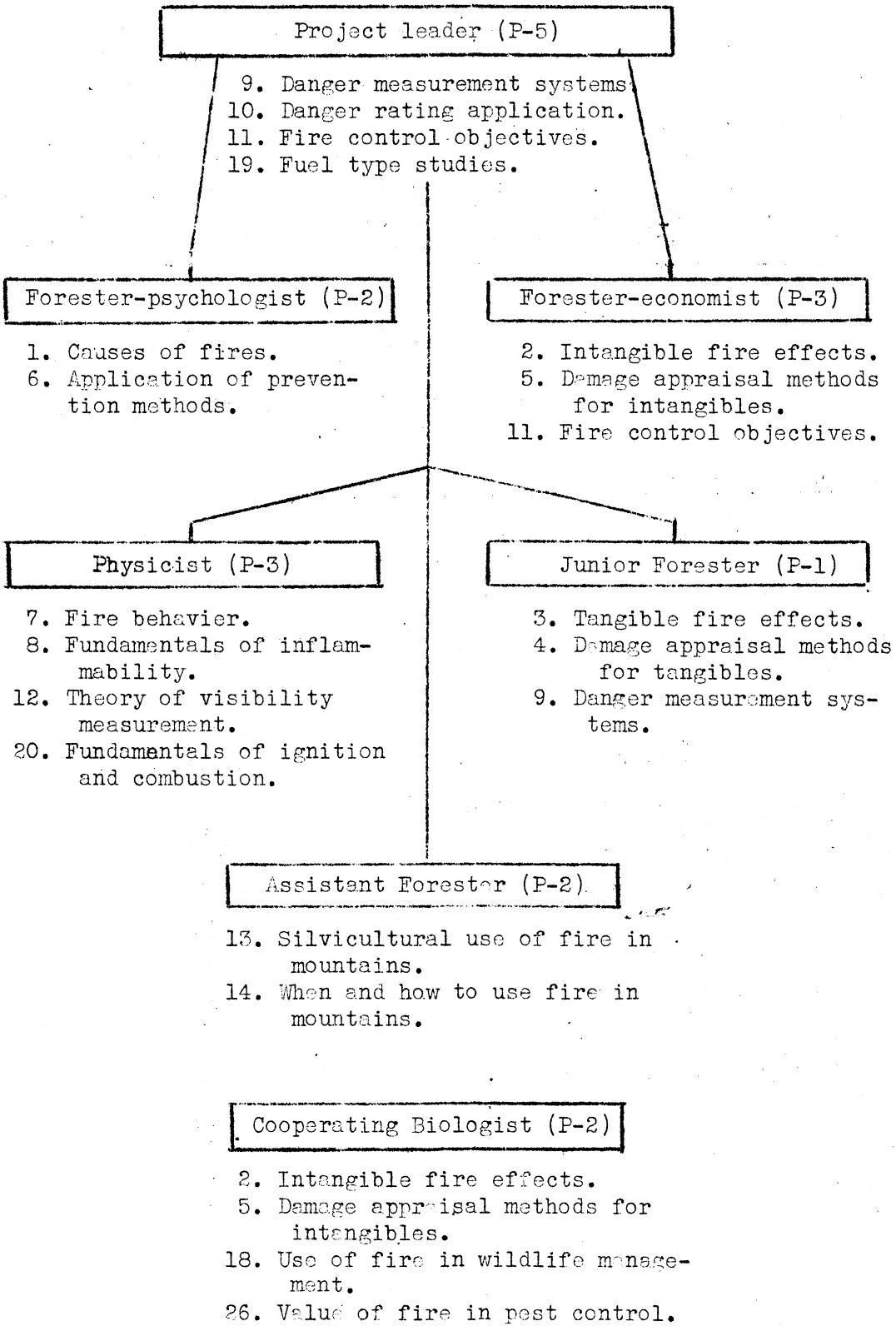
A suggested program with these additions to the present staff would be as follows with assignments as shown by the accompanying diagram (figure 20). Study numbers are the same as those listed in table 18. Duplicate entries of an individual study indicate that it would be the joint responsibility of the parties shown.

Probable accomplishments under expanded program

As shown by the diagram, work could be started on the first 14 studies as well as two of lower priority if the fire research staff were expanded as indicated. A cooperating biologist could assist on two high and two other lower priority jobs. In the following table an estimate is made of what portion of each study could be completed in five years.

Fire Project Studies	Percent completed in 5 years
1. Underlying causes of fire occurrence.	60
2. Determination of intangible fire effects.	50
3. Determination of tangible fire effects.	100
4. Damage appraisal methods for tangibles.	100
5. Damage appraisal methods for intangibles.	25
6. Application of prevention methods.	30
7. Basic fire behavior studies.	40
8. Fundamental studies of inflammability.	70
9. Danger measurement systems.	90
10. Application of danger ratings to fire control.	90
11. Economic fire control objectives.	60
12. Theory of visibility measurement.	100
13. Silvicultural value of controlled fire in mountains.	75
14. Determination of when and how to use fire in mountains.	75
19. Fuel type studies of rate of spread.	100
20. Fundamentals of ignition and combustion.	50
Studies for Cooperating Biologists	
2. Determination of intangible fire effects.	50
5. Damage appraisal methods for intangibles.	25
18. Use of fire in wildlife management.	30
16. Value of fire in pest control.	50

Figure 20.-Assignment of studies to an expanded fire project staff.



The costs

Annual costs for the expanded program would be as follows:

Salaries.-technical personnel.-		
Project leader (P-5)	$4,600	
Forester-economist (P-3)	3,200	
Physicist (P-3)	3,200	
Forester-psychologist (P-2)	2,600	
Assistant forester (P-2)	2,600	
Junior forester (P-1)	2,000	
		$ 18,200
Salaries.-office and temporary personnel.-		
Project stenographer	$1,620	
Computer	1,620	
Field assistants (2 man-years annually)	2,880	
		6,120
Travel.-		2,000
Equipment, supplies, and miscellaneous.-		2,680
Grand total per year		$ 29,000
Cooperating biologist.-		5,000

Justification of an Expanded Program

Justification for an expanded forest fire research program may be found in statistics presented early in this report. There can be no question that the Appalachian region has a long way to go yet before the fire problem even approaches a satisfactory solution - the figures —

44,000	fires per year
6.8	million acres burned per year
51	percent of forest land unprotected
$8,000,000	annual tangible damage.

The most reliable figures available indicate that the annual expenditure for all phases of fire prevention and control in the region approximates $1,500,000. For the national forests, indirect fire control costs, such as maintenance and depreciation of structures, roads,

tracts, telephone lines, etc., are just twice as great as the expenditures for prevention and suppression. Thus, a very conservative figure for direct and indirect costs would be from $3,000,000 to $4,000,000. The total damage plus protection costs approximates $12,000,000 per year and this does not include intangible damage which at present cannot be evaluated.

Thus, we are spending $10,000 to $11,000 this year for research in a field that costs at least 1,000 times that amount annually. With all the promise that fire investigations have for reducing protection costs and damages, doubling or trebling the fire research allotment would be good business.